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OCTOBER 1926

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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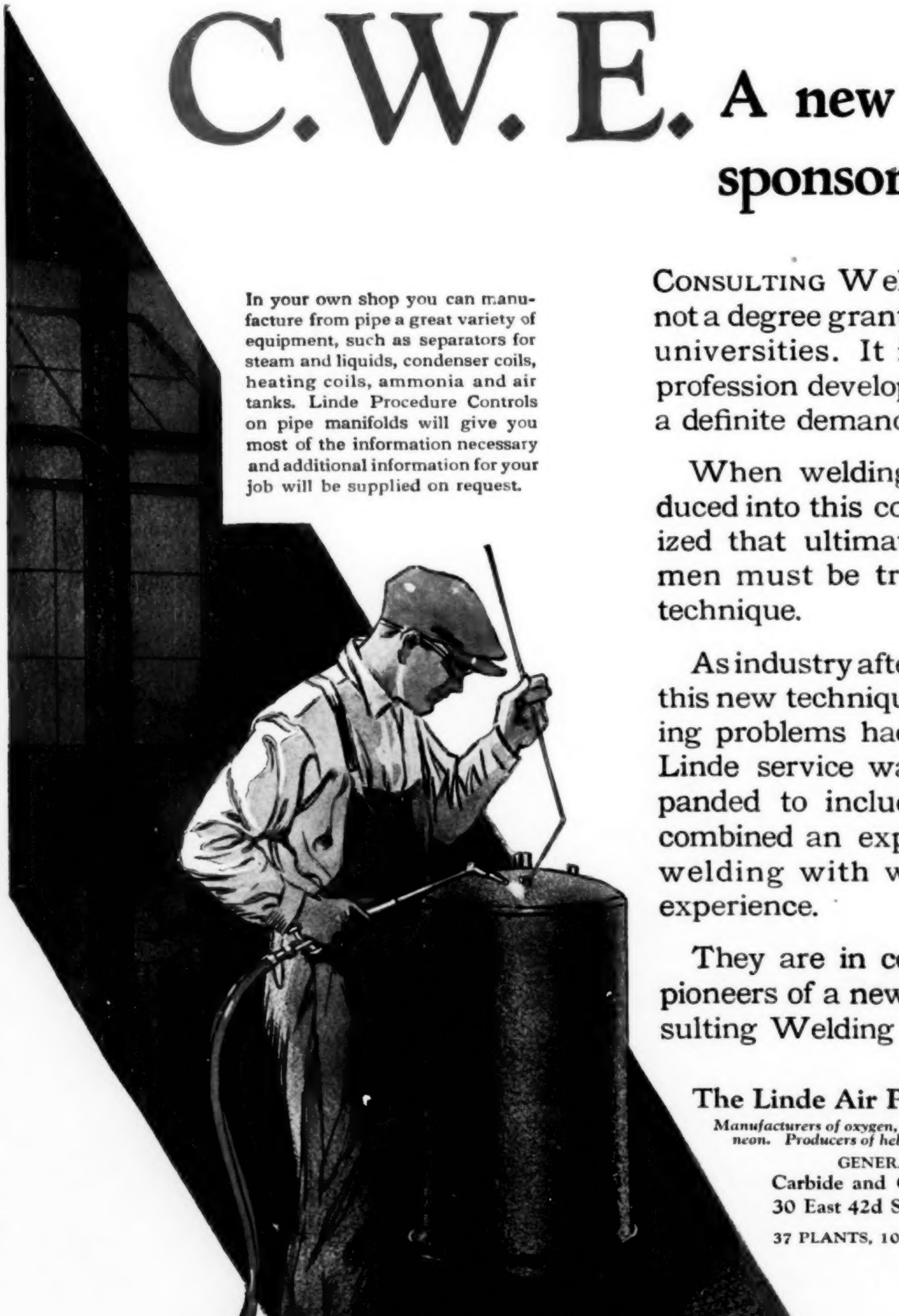

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ADVERTISING

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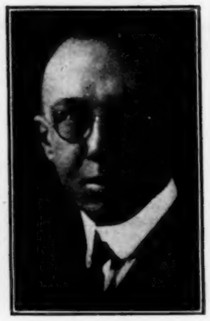
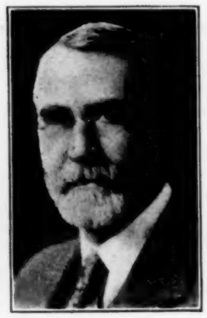
J. C. Hayes, Jr.

F. H. Willcox



F. N. Speller



C. T. Main

H. L. Seward

H. W. Leitch

Contributors to this Issue

Herbert L. Seward was educated at Yale University, from which he received his Ph.B. degree in 1906 and M.E. degree in 1908. Since his graduation he has been continuously a member of the teaching staff of the Sheffield Scientific School at Yale, with the exception of the World War period, when he developed and operated the U. S. Navy Steam Engineering School at Stevens Institute, with the rank of lieutenant commander, U.S.N.R.F. He is now associate professor of mechanical engineering at the Sheffield Scientific School.

* * * * *

Charles T. Main, engineer and designer of industrial plants, was graduated from Massachusetts Institute of Technology in 1876. For eleven years he was connected with the Lower Pacific Mills, Lawrence, Mass., directing its reorganization and rebuilding. From 1893 until 1907 he was associated with F. W. Dean in the firm of Dean & Main. Since that time he has been engaged in independent operations in his own name. He is a past-president of the A.S.M.E.

* * * * *

H. W. Leitch was graduated from the Polytechnic Institute of Brooklyn, and has been identified with large generating stations since 1902. He was one of the original operators at the 74th Street Station of the Interborough Company and later was connected with the Waterside Stations of the Edison Company. Mr. Leitch entered the employ of the United Electric Light and Power Company in 1913 as electrical superintendent and later was appointed the first superintendent of the Sherman Creek Station. He is now general superintendent of power plants of that company.

* * * * *

F. M. Gunby, associated with Charles T. Main, Boston, is a graduate of Clemson Agricultural and Mechanical College. He served as draftsman with the Eagle & Phoenix Mills, Columbus, Ga., and in 1905 entered the employ of Mr. Main as draftsman, later becoming head of the electric department and then engineering manager in charge of the design and supervision of construction of many large industrial and power plants.

* * * * *

J. A. McKeage was graduated from Cornell University in 1916 with the degree of M.E. After graduation he entered the employ of the General Chemical Co., in their New York office, and served with them in their power-plant and operating divisions until 1920. Since then he has been with the Beach Manufacturing Co., of Montrose, Pa., manufacturers of sawing machinery, and is now their secretary and chief engineer.

* * * * *

F. N. Speller, metallurgical engineer with the National Tube Co., Pittsburgh, Pa., is a graduate of the University of Toronto. After several years of general engineering experience, he became connected with the National Tube Company and is now in charge of their Metallurgical Research Department. He has been identified with improvements in manufacture of steel tubing, and important new developments for the abatement of corrosion in water systems.

* * * * *

W. H. McAdams, associate professor in the department of chemical engineering in the Massachusetts Institute of Technology, received his B.S. from the State University of Kentucky in 1913 and his S.M. from M.I.T. in 1917. During the War he served in the Chemical Warfare Service of the U. S. Army, afterwards becoming assistant professor of chemical engineering at M.I.T.

T. K. Sherwood has been associated as research associate in the department of chemical engineering of Massachusetts Institute of Technology. He is a graduate of McGill University in Montreal. He has also served as an instructor in chemical engineering at Worcester Polytechnic Institute and as development engineer with the Hood Rubber Co., Watertown, Mass.

* * * * *

F. H. Willcox, vice-president of the Freyn Engineering Co., Chicago, has been associated with that concern for the past nine years as secretary. He was formerly associated with the United States Bureau of Mines as metallurgical engineer and prior to that was with the Carnegie Steel Co. For six years he served as engineer and assistant blast-furnace superintendent of the National Tube Co.

* * * * *

J. C. Hayes, Jr., has been associated with the Freyn Engineering Co., Chicago, for the past ten years as field engineer, more lately holding the position of mechanical engineer. Prior to that Mr. Hayes was for eleven years at the South Works of the Illinois Steel Co. as operating and supervising engineer.

* * * * *

F. L. Kallam, mechanical engineer specializing in natural-gas gasoline extraction plants, in Long Beach, Cal., is a graduate of Stanford University. He has been connected with several companies in Southern California, including the Pan American Petroleum Corporation, the Shell Company of California, the Southwest Gasoline Company, the California Gasoline Company, the Mutual Gasoline Company.

* * * * *

W. C. Bell, general manager and chief engineer of the Virginia Electric & Power Co., Richmond, Va., was graduated from the University of California. In 1911 he became connected with the Pacific Gas & Electric Co. and served as superintendent of construction, mechanical and electrical engineer, chief engineer and purchasing agent.

T. K. Sherwood

J. A. McKeage

F. L. Kallam

MECHANICAL ENGINEERING

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Fuel Conservation in the United States Government Merchant-Marine Fleet

By HERBERT L. SEWARD,[1] NEW HAVEN, CONN.

IN JULY, 1922, there were approximately 400 merchant-marine vessels owned by the United States Government being operated by 39 operating companies on a large number of regular lines. Our government was then, and is now, operating the biggest shipping business ever known. The total annual fuel bill of these vessels was approximately $35,000,000. The fleet included many different types of vessels; the ex-German ships, the 535's, the 502's, Hog Islands, Federals, and many others.

The importance of conserving fuel and of developing the most economical methods of operation were so evident that in July, 1922, there was organized in the operating department of the Shipping Board a Fuel Conservation Committee which immediately gave these matters some very careful and constant study. This committee was composed of representatives of the following groups:

- Department of Maintenance and Repair, United States Shipping Board
- Fuel Section, United States Shipping Board
- The Society of Naval Architects and Marine Engineers
- The American Society of Mechanical Engineers
- The American Bureau of Shipping
- The American Marine Congress
- The Marine Engineers Benevolent Association
- The Operating Managers of United States Shipping Board vessels
- Marine Publications

The following men are members of this committee at present:

- Captain C. A. McAllister, U.S.C.G., *Chairman*
- Captain R. D. Gatewood, U.S.N., *Vice-Chairman*
- Colonel G. Bartlett
- Major G. M. Talbot
- Professor H. L. Seward
- Mr. E. H. Peabody
- Mr. James Swan
- Mr. F. B. Webster
- Mr. J. J. Fagan

There is not space in this paper for a proper record of the early work done by this committee and it is to be regretted that ample individual credit cannot be given to those men on the committee and to their subordinates who have done such excellent work.

In order to put the committee program into action, a Fuel Conservation Section was created with headquarters in New York City and representatives in the other important ports as the work progressed. The difficult post of head of this section was assigned to C. J. Jefferson, an appointment which has given both the committee and the entire marine-engineering fraternity the greatest satisfaction. The writer is indebted to Mr. Jefferson for the statistical information included in this paper. The spirit of service which has been shown by the personnel of the Fuel Conservation Section is noteworthy and above praise in their loyalty to the ideal of bringing American marine practice up to the best levels attainable.

[1] Associate-Professor of Mechanical Engineering, Sheffield Scientific School of Yale University, Member Fuel Conservation Committee, United States Shipping Board representing A.S.M.E. Mem. A.S.M.E.

For presentation at the Old Dominion Meeting, Richmond, Va., September 27 to 30, 1926, of The American Society of Mechanical Engineers.

Power-plant practice ashore had been making rapid strides toward higher operating economies but by the nature of the case, this advance had not been paralleled afloat. The marine engineer emphasizes reliability and his plant *must* operate. He is given a certain combination of equipment, located in constricted spaces, and supplied with a certain kind of fuel, and with this he is expected to furnish propulsion, heat, refrigeration, light, fresh water, and many other services in a sure and steady manner. His staff is subjected to a tremendously high turnover and he naturally has to train it to operate and attend the machinery before he can develop the best in economy and begin to conserve fuel.

As the basis of any system of inspection should be the comparison of a performance with an established standard, it became necessary to set up standards of performance. These standards had to be reasonable working standards capable of being attained under actual conditions of varied types of service with the available seagoing personnel, and yet not involving a large technical staff ashore. There was not time for extended investigations and the compilation of data, nor were there any data available at that time from which standards could be obtained.

A voyage is composed of a series of passages at sea between pilot stations and a series of periods in port. The standard unit adopted in analyzing the various sea passages was "observed miles per ton of fuel." The observed miles (or actual nautical distance made good by the ship) were chosen rather than the propeller miles (revolutions times pitch) because the object of this inspection was not only to determine the performance of the engineers' department, but also to determine the efficiency of the vessel as a whole, and efficiency will be affected by the work of the navigator and helmsman as well as by the performance of the propelling machinery and auxiliaries. If the shaft horsepower could have been easily determined in a continuous manner, or its average value known for each passage, the fuel per shaft horsepower-hour would have been a desirable engineering standard unit.

Inspection Methods of Fuel Conservation Section

The methods developed by the Fuel Conservation Section are so well described in a paper presented by J. E. Sheedy before the Society of Naval Architects and Marine Engineers in New York in November, 1923, that the substance of the following paragraphs is taken from that paper.

In order to obtain a standard for the distance steamed per ton of fuel, it is necessary first to obtain the power required to drive the ship at different draughts and speeds. This is done by obtaining the effective horsepower necessary under ideal conditions and adding a percentage to it in order to allow for average sea conditions. This increase in resistance is due to two items: (1) The condition of the ship's bottom, and (2) the effect of wind and sea. The first can be approximated with some degree of accuracy, but the second can only be very roughly estimated. After some investigation it was decided that the percentage increase in resistance decreased as the draught increased, and the following, as shown in Table 1, was adopted as a standard.

Having obtained the approximate effective horsepower necessary under average sea conditions, the shaft or indicated horsepower is calculated.

TABLE 1

Draught-beam ratio	Percentage increase	Draught-beam ratio	Percentage increase
0.25	31.7	0.45	25.0
0.30	30.0	0.50	23.3
0.35	28.3	0.55	21.6
0.40	26.7	0.60	20.0

For this calculation the familiar Dyson method of propeller analysis is used.

The next step is to obtain the fuel rate of the machinery under various conditions, after which the total fuel per hour and the nautical miles per ton of fuel are determined.

Before a standard of fuel rate can be established, certain items have to be determined as a basis of good operation. These are feedwater temperature, the heating values of the fuel, and the efficiencies of the boiler when either oil or coal is used. The standards of each are given below for the average cargo carrier:

Feedwater temperature, deg. fahr.	210
Heating value of oil, B.t.u. per lb.	18,500
Heating value of coal, B.t.u. per lb.	13,500
Efficiency of boiler burning oil	0.75
Efficiency of boiler burning coal	0.66

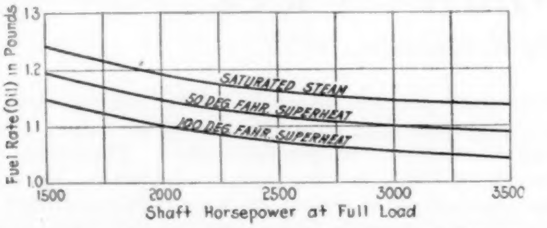


Fig. 1 Fuel Rates for Cargo Ships—Turbine Driven

(Pressure at nozzles 185 lb. gage; vacuum 28 in. at 30-in. barometer. For coal, fuel rate = 1.58 × fuel rate for oil. Evaporation per pound of fuel oil = 13.5 lb. Evaporation per pound of coal = 8.55 lb.)

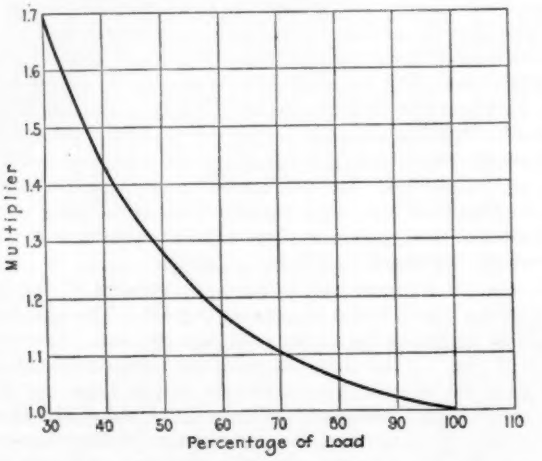


Fig. 2 Fuel-Rate Multipliers—Turbine-Driven Cargo Ships for Determination of Corrected Fuel Rates at Various Percentages of Loads

The boiler pressure is taken at 200 lb. per sq. in. gage, as this pressure is used on most of the cargo ships owned by the Emergency Fleet Corporation. With this boiler pressure, feedwater temperature, heating values of fuel, and boiler efficiency as given, the actual evaporation will be 13.5 pounds of water per pound of fuel oil and 8.55 pounds per pound of coal. The boiler efficiencies and evaporations may seem low when compared with tests or stationary-plant practice, but due to the fact that the turnover in the fireroom crew is greater than that experienced in stationary plants and to the impossibility of obtaining as good results in operation as are obtained on tests, the above figures appear to be fair values to use.

The water rates for the main engines or turbines and the auxiliaries of various sizes were determined from test data, and using the above figures for evaporation the curves on Figs. 1, 3, and 4, were drawn. These curves are based on the following assumptions: (1) The auxiliaries use saturated steam. (2) All of the auxiliaries are of the approved marine type. (3) The machinery is kept in reasonably good repair and is operated with a reasonable degree of intelligence. (4) The steam pressure of the turbine inlet or the high-pressure steam chest of a triple-expansion engine is 185 lb. per sq. in. gage and the vacuum is 28 in. of mercury for turbines and 25 in. for reciprocating engines. The curve for quadruple engines as shown in Fig. 4 is based on 200 to 205 lb. per sq. in. gage at the high-pressure chest. If the steam pressure varies materially from the figures given, corrections should be made. Should the ship be fitted with auxiliaries of different type, or the burners be of an antiquated or inferior design, allowances should be made.

When the ship is being operated at fractional loads the water rates vary from that at full load, and the evaporation of water per pound of fuel will also vary. The latter, however, is neglected, as the average variation is too small to be taken into account. The corrections for fractional loads for turbine-driven ships are shown in Fig. 2, while those for reciprocating-engine ships are given in Fig. 5.

In order to illustrate the method used to obtain the fuel rate and the amount of fuel used for one hour the following examples are given:

Example 1. Given a 2500-shaft-horsepower turbine using steam at 185 lb. per sq. in. gage at the turbine inlet, 60 deg. fahr. superheat at the throttle, and 28 in. of vacuum. Find the fuel rate and the fuel used per hour at various loads, oil being used as fuel.

From Fig. 1 the fuel rate at 100 per cent load is found to be 1.11. For other than 100 per cent load this value should be multiplied by the correction factor shown on Fig. 2. The calculations are shown in Table 2, for which the curves of Fig. 6 were drawn.

TABLE 2 CALCULATIONS FOR EXAMPLE 1

(1) Per cent of load	(2) Shaft horsepower	(3) Multiplier (Fig. 2)	(4) = 1.11 × (3) Fuel rate, oil, lb. per s.hp-hr.	(5) = (2) × (4) Fuel per hour, lb.
110	2750	0.991	1.100	3025
105	2625	0.995	1.104	2 98
100	2500	1.000	1.110	2775
95	2375	1.010	1.121	2662
90	2250	1.023	1.136	2552
80	2000	1.057	1.173	2347
70	1750	1.105	1.226	2147
60	1500	1.175	1.305	1958
50	1250	1.284	1.425	1781
40	1000	1.440	1.598	1598

Example 2. Given a 2800-indicated-horsepower triple-expansion engine with short ports and small clearances, using saturated steam at 185 lb. per sq. in. gage at the high-pressure chest. Find the water rates and fuel used per hour at various loads, oil being used as fuel.

From Fig. 4 the fuel rate at 100 per cent load is found to be 1.163, and the correction factors for other loads are found on Fig. 5. The calculations are shown on Table 3, from which the curves on Fig. 7 were drawn.

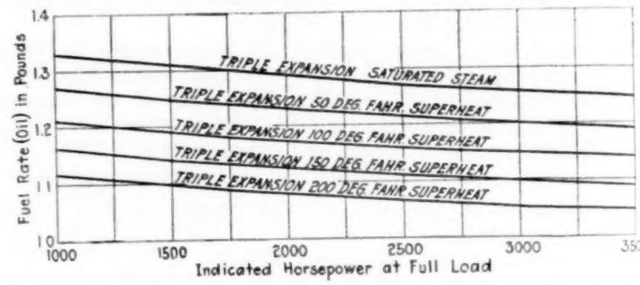


Fig. 3 Fuel Rates for Cargo Ships Driven by Reciprocating Engines with Long Ports and Large Clearances

(For coal, fuel rate = 1.58 × fuel rate for oil. Evaporation per pound of fuel oil = 13.5 lb. Evaporation per pound of coal = 8.55 lb.)

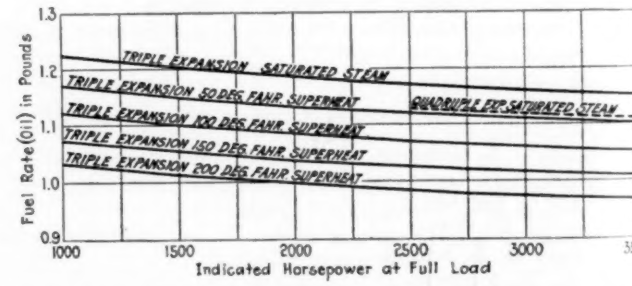


Fig. 4 Fuel Rates for Cargo Ships Driven by Reciprocating Engines with Short Ports and Small Clearances

(For coal, fuel rate = 1.58 × fuel rate for oil. Evaporation per pound of fuel oil = 13.5 lb. Evaporation per pound of coal = 8.55 lb.)

TABLE 3 CALCULATIONS FOR EXAMPLE 2

(1) Per cent of load	(2) Indicated horsepower	(3) Multiplier (Fig. 5)	(4) = 1.163 × (3) Fuel rate, oil, lb. per hp-hr.	(5) = (2) × (3) Fuel per hour lb.
110	3080	1.025	1.192	3670
105	2940	1.012	1.177	3460
100	2800	1.000	1.163	3256
95	2660	0.992	1.153	3067
90	2520	0.900	1.151	2900
85	2380	0.991	1.152	2740
80	2240	0.998	1.160	2598
70	1960	1.015	1.180	2313
60	1680	1.039	1.208	2030
50	1400	1.078	1.253	1755
40	1120	1.143	1.328	1487

If coal were used in place of oil, the fuel used per hour would be as found in column 5 multiplied by 1.58.

Having found the fuel used per hour for the different powers and knowing the power necessary for the various speeds and draughts, the miles steamed per ton of fuel are obtained as shown in the following example:

Example 3. For this example one of the 7500-deadweight-ton ships built by the American International Corporation known as the Hog Island type A ships will be taken. These ships are fitted with 2500-shaft-horsepower turbines of the impulse type and water-tube boilers built for 200 lb. working pressure and 60 deg. fahr. superheat, and are fitted to burn oil fuel. The amount of fuel used per hour for various powers is taken from Fig. 6. As the method used for estimating the mileage per ton of fuel is the same for

the different draughts, the calculations for the 25-ft. draught only are shown, which are as follows:

Speed in knots	12	11.5	11	10.5	10	9.5	9
Shaft horsepower as obtained from propeller analysis	3530	3045	2615	2225	1897	1600	1353
Fuel per hour in pounds from Fig. 6	....	3340	2857	3530	2265	2025	1850
Nautical miles per ton of fuel = speed × 2240 divided by fuel per hour in pounds	....	7.71	8.63	9.30	9.89	10.51	10.90

After the mileage per ton of fuel is calculated, curves as shown on Fig. 8, are drawn.

Performance of a Ship on a Voyage

The procedure for obtaining the performance of a ship on a voyage is as follows:

Divide the distance (in nautical miles) traveled, by the fuel (in tons) consumed. This will give the actual miles per ton of fuel. From the chart (Fig. 8) find the standard nautical miles per ton of fuel for the draught and speed on this voyage. Divide the actual performance by the standard and multiply by one hundred. This will give the percentage performance for the voyage.

Example 4. To find the percentage performance of a Hog Island type A ship on a voyage:

Mean draught on leaving port	24 ft. 0 in.
Mean draught on arriving	23 ft. 0 in.
Mean draught on voyage	23 ft. 6 in.
Distance traveled, nautical miles	3000
Fuel consumed, tons	310
Speed, knots	10.2

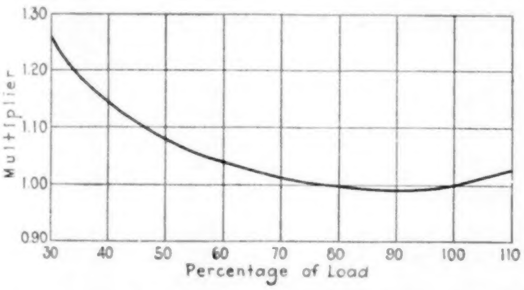


FIG. 5 FUEL-RATE MULTIPLIERS FOR CARGO SHIPS WITH RECIPROCATING ENGINES FOR DETERMINATION OF CORRECTED FUEL RATES AT VARIOUS PERCENTAGES OF LOAD

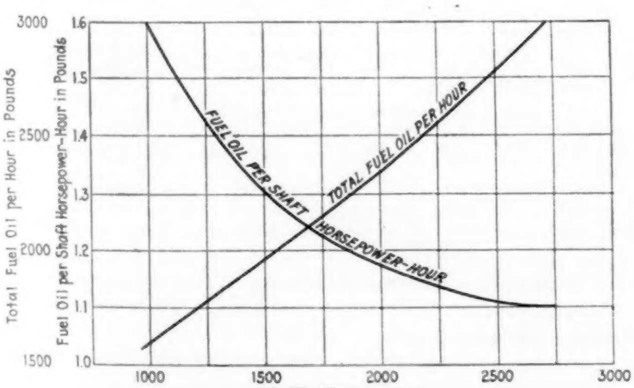


FIG. 6 FUEL CONSUMPTION—2500-SHAFT-HORSEPOWER TURBINE

$$\text{Actual nautical miles per ton of fuel} = \frac{3000}{310} = 9.68$$

Standard nautical miles per ton of fuel for 10.2 knots and 23 ft. 6 in. draught (from curves) = 9.95.

$$\text{Percentage performance of passage} = \frac{9.68 \times 100}{9.95} = 97 \text{ per cent.}$$

In order to obtain the average performance, the efficiency of each passage is multiplied by the distance steamed and these products are added, then divided by the total distance steamed, an example of which is given in Table 4.

As the work progressed it was found that the efficiencies were lower at the lighter draughts, due to the propeller being too near the water surface. In order to correct for this the theoretical mileage per ton of fuel is taken at a draught equal to the diameter of the propeller plus 10 per cent when the actual mean draught was less than this figure. Some other practices first announced in Mr. Sheedy's paper have been so revised by later experience that they will be discussed later on in the present paper.

TABLE 4 CALCULATIONS FOR EXAMPLE 4

(1) Draught, ft-in.	(2) Observed speed, knots	(3) Tons fuel per 24 hr.	(4) Nautical miles per ton of fuel: Actual	(5) Nautical miles per ton of fuel: Theoretical	(6) = (4) ÷ (5) Efficiency, Per cent	(7) Length of passage, nautical miles	(8) = (7) × (6)	(9) Weather
20–7½	10.48	26.90	9.35	10.19	91.8	3,200	293,800	Good
22–3½	11.39	29.20	9.35	8.64	108.3	1,500	162,500	Good
22–4¼	11.26	27.09	9.97	8.84	112.8	2,000	225,600	Good
22–8½	10.03	29.90	8.05	10.32	78.0	3,300	275,500	Good
22–9½	10.63	32.61	7.82	9.60	81.5	3,200	261,000	Rough seas and head wind
22–10½	11.84	33.41	8.51	7.78	109.4	1,800	196,900	Good
23–0	11.23	32.99	8.17	8.78	93.1	2,500	232,800	Fair
Total						17,500	1,630,100	

$$\text{Average efficiency} = \frac{1,630,100}{17,500} = 93.1 \text{ per cent.}$$

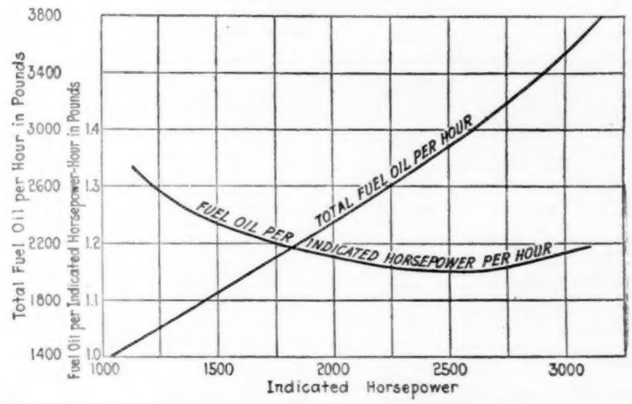


FIG. 7 FUEL CONSUMPTION—2800-INDICATED-HORSEPOWER, TRIPLE-EXPANSION ENGINE, EMERGENCY FLEET CORPORATION STANDARD
(Size of cylinders 24½ in. × 41½ in. × 72 in. × 48 in. Saturated steam.)

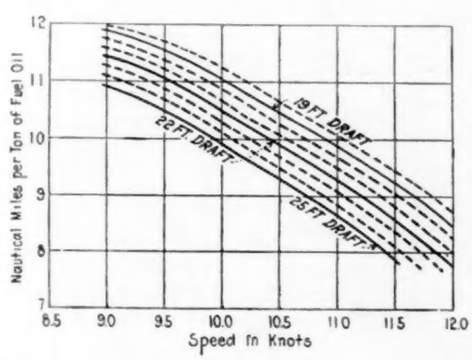


FIG. 8 PERFORMANCE STANDARDIZATION TYPE A SHIPS AMERICAN INTERNATIONAL SHIPBUILDING CORPORATION
(Curtis turbine, design No. 1022.)

Fig. 8 illustrates the standard curve derived for only one class of ships. It was necessary to develop 76 standard curves for all types or individual cases. A large amount of this work of developing sea standards was done by E. S. Stevens, Jr., who was then a member of the committee. The standards, while not absolutely correct, do afford a working basis for the comparison of the performance of similar ships under like conditions. It is not expected that the ships will reach values given by these curves on every voyage: rough weather will decrease the mileage, and smooth weather will permit the values to be exceeded, but the average performance should approach the standards provided that the ships and machinery are in proper condition and properly operated. The poorer performers of any class of ship can be detected and the chronological performance of all ships can be watched for improvement or decline.

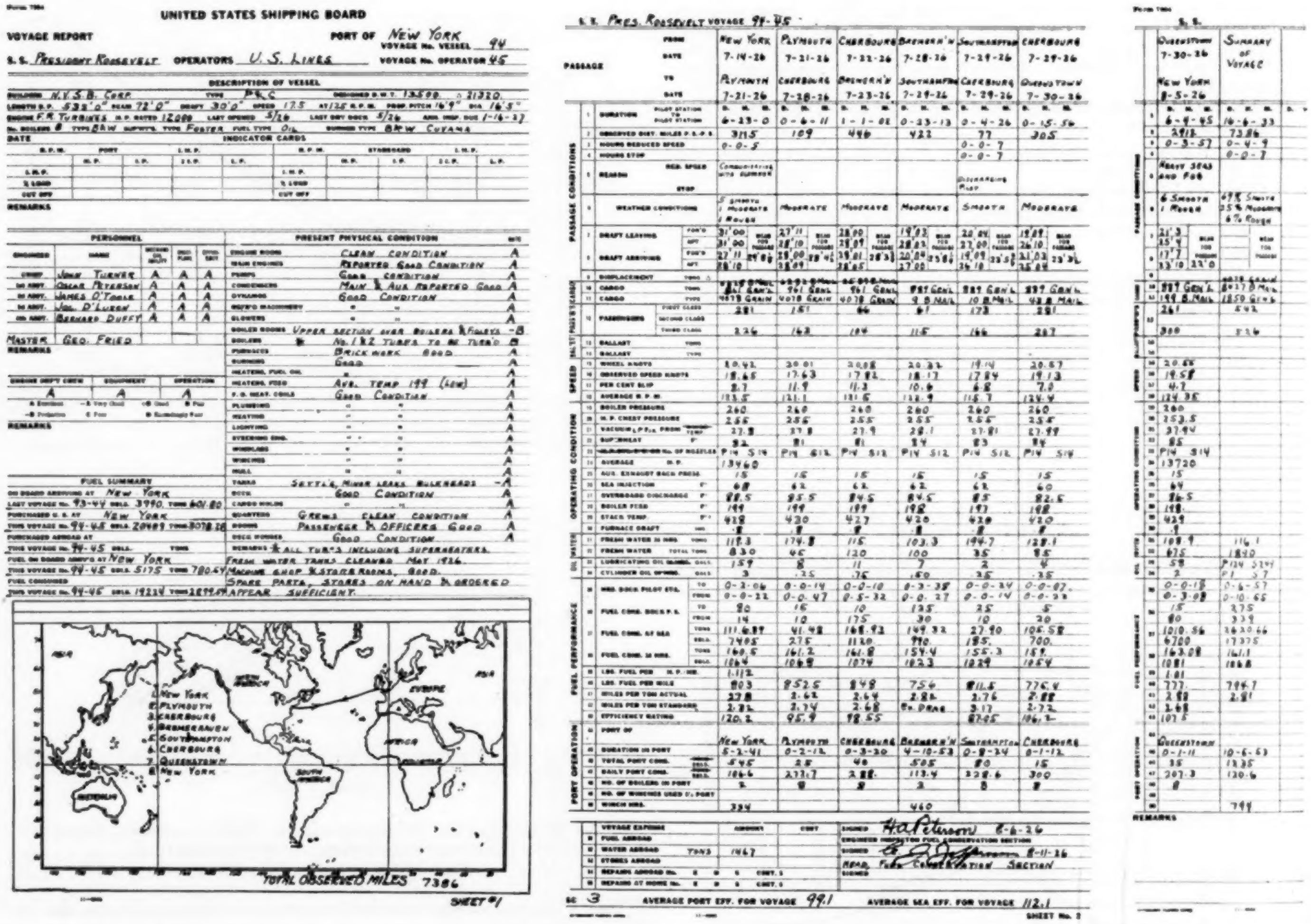
Inspection of Active Vessels

With the standards of performance at sea determined, it was necessary to organize a systematic inspection of the active vessels of the fleet. The inspector must be able to size up the conditions on board the vessel, give the log some very careful scrutiny, and be able to analyze this record of performance promptly during the next stay of the vessel in port. From the continuous record of the vessel's performance it should be determined whether or not an

improvement in operation is being made, and what effects any modifications made in the equipment of the vessels or in methods of operation have on the ship's performance. The operators receive prompt notice of the performance on each voyage of each of their vessels and are held responsible to the Government for economy of operation.

The Manual of Instructions for Engineer Inspectors, Fuel Conservation Section is very complete and has recently been published in *Marine Engineering and Shipping Age*.

The voyage report now used by the inspectors is shown in Fig. 9. This is typed on blue printing paper so that the necessary duplicates are easily made for operators, chief engineers, department of the bunkering and consumption of the vessel and checks the fuel consumption, which is shown on the second page under headings of Sea Consumption, Port Consumption, and Consumption in Pilot Waters. The second page is given over to the operating conditions on which are recorded the chief items that affect the economy of operation of the engine department. The data tabulated in each of the several columns represent the conditions of each of the passages of the voyage. A summary of the voyage is given in the last column. The last available voyage report of the popular *S. S. President Roosevelt* of the United States Lines at the time of writing this paper was chosen to illustrate the use of the regular voyage report and it is reproduced exactly as originally made out.


UNITED STATES SHIPPING BOARD

VOYAGE REPORT PORT OF New York VOYAGE No. VESSEL 94

S. S. President Roosevelt OPERATORS U. S. Lines VOYAGE No. OPERATOR 45

DESCRIPTION OF VESSEL

INDICATOR CARDS

PERSONNEL — PRESENT PHYSICAL CONDITION

FUEL SUMMARY

TOTAL OBSERVED MILES 7386

SHEET #1

S. S. Pres. Roosevelt VOYAGE 94-45

PASSAGE							
FROM	New York	Plymouth	Cherbourg	Bremerh'n	Southampton	Cherbourg	Queenstown
DATE	7-14-26	7-21-26	7-22-26	7-28-26	7-29-26	7-29-26	7-30-26
TO	Plymouth	Cherbourg	Bremerh'n	Southampton	Cherbourg	Queenstown	New York
DATE	7-21-26	7-28-26	7-23-26	7-29-26	7-29-26	7-30-26	8-5-26

PASSAGE CONDITIONS — SPEED — OPERATING CONDITION — FUEL PERFORMANCE — PORT OPERATION

AVERAGE PORT EFF. FOR VOYAGE 99.1 AVERAGE SEA EFF. FOR VOYAGE 112.1

SHEET No. 2

SUMMARY OF VOYAGE

FIG. 9 VOYAGE REPORT, UNITED STATES SHIPPING BOARD

heads, and the files. The first page of this form is headed with a brief description of the physical characteristics of the vessel, which serves to classify the type of the particular vessel covered by the report. Following this is an analysis of indicator cards which is filled out for steam-driven reciprocating-engine vessels. A brief report of the physical condition of the various departments and equipment of the vessel is given, together with a rating based on an *A, B, C, D* schedule. The engineer officer personnel is also rated under three headings, mechanical ability, discipline, and efficiency, these ratings to represent the degree of each of the above characteristics shown on this particular voyage. The engine-department crew, its equipment, and the operation of the vessel are also rated on the same schedule. In order that the above ratings shall be of real value, the inspection must be made by a competent, experienced, and well-selected inspector, who will make an unbiased report entirely free from any personal prejudice. At the lower part of this page is given an outline chart of the world, upon which is shown the particular route in which the vessel operates. This chart is used simply as a quick means of route classification. On this first page is also the fuel summary, which gives a continuous record

Through this system of inspection close touch is kept with the operating vessels of the fleet, and it becomes a comparatively simple matter to determine the relative performance of any particular vessel at any time and to direct the efforts for improvement towards the poorer performers so as to bring them up to the standard of their sister ships. A report such as this, made at the termination of each voyage of a vessel, has a marked beneficial effect on the efforts of the operating personnel. They are not only kept advised as to their own performance, but also of those of their sister ships. This stimulates that competitive spirit which is so characteristic of the American engineer and which enables him to overcome seemingly impossible obstacles. It is apparent also that by means of these inspection reports it becomes comparatively easy to determine from an operating standpoint the relative standard of operating efficiency of the managing operators, and in this way materially to assist in arriving at a decision as to which operators are sufficiently competent to continue to handle the Fleet Corporation vessels.

Port Standards

The standards so far described have been applicable to sea

conditions only, but in order to prevent any erroneous distribution of fuel consumption between sea and port conditions whereby the chief engineers might be subjected to the temptation of covering up excessive sea consumption by reporting it under port consumption, the various port standards were next developed.

Again, due to the difficulties of measurement and to the impracticability of determining the exact performance of deck winches, dynamos, ice machines, blowers, pumps, and all other auxiliaries for each vessel for every port condition, it was decided to make a series of standard allowances for average port conditions. These standard allowances, K_1, K_2, K_3, etc., are each multiplied by their particular factors and summed up to give a standard port consumption. This, divided by the actual amount of the fuel consumed, gives the port efficiency, as follows:

$$\text{Port efficiency} = \frac{K_1 \times \text{tons of cargo handled} + K_2 \times \text{fuel bunkered} + \text{etc.}}{\text{Total port consumption}}$$

K_1 = 7.5 lb. oil per ton of cargo handled
K_2 = 0.452 lb. per bbl. pumped +0.1 lb. per ton per deg. fahr. heated
K_3 = allowance per hour for ship's use, 200 to 5000 lb.
K'_2 = extra cargo allowance such as logs from water
K'_3 = open port conditions
K_4 = refrigerated cargo = 358 lb. per refrigerating ton machine-hour
K_5 = pumping ballast, 1.5 lb. per ton
K_6 = transfer for pressing tanks, 1.5 lb. per ton
K_7 = steaming tanks (see chart)
K_8 = moving ship, from 1750 to 6500 lb.
K_9 = dock trials
K_{10} = deck steam, freezing weather, 15 lb. per winch-hour

In determining K_1, the allowance for cargo handling, it was found that there was so little difference in steam consumption of a steam winch when hoisting and when lowering cargo that the total cargo loaded and unloaded for the stay in port called "tons of cargo handled" was a fair unit. Vessels equipped with electric winches or with better types of deck equipment, as well as the season of the year, are made the subject of suitable variations in the values of K_1 applied. The values of K_1 were originally determined from steam-consumption tests of various types of winches. The horsepower values for various types of cargo were determined quite well from vessels fitted with electric winches.

The K_2 value was determined by actual tests of pumping fuel oil aboard ships, as well as by actually heating barges of fuel oil.

The determination of K_3 for the several types of ships was more difficult because of the varied conditions to be met. A few hours in port under stand-by conditions will require a considerably greater amount of fuel than will be the case when the vessel is in port several days and is able to get down to true port operation. Therefore the value of K_3 is made to apply to all of the port stays of the entire voyage. It is in this quantity that the thoughtful operating engineer can usually produce some real savings.

Fuel Economies in Port Consumption

Development of fuel economies in port consumption presents several difficulties of somewhat different nature than those met with in the sea performance. When the vessel arrives in port there is a let-down in the morale of the operating personnel which militates against efficiency. The operation of boilers economically under the reduced load of port service calls for greater attention so as to avoid high excess-air conditions with their resultant decreased combustion efficiency. Coöperation between deck and engine departments is most essential so as to prevent unnecessary use of deck steam with its attending losses due to line condensation, minor leaks, etc.

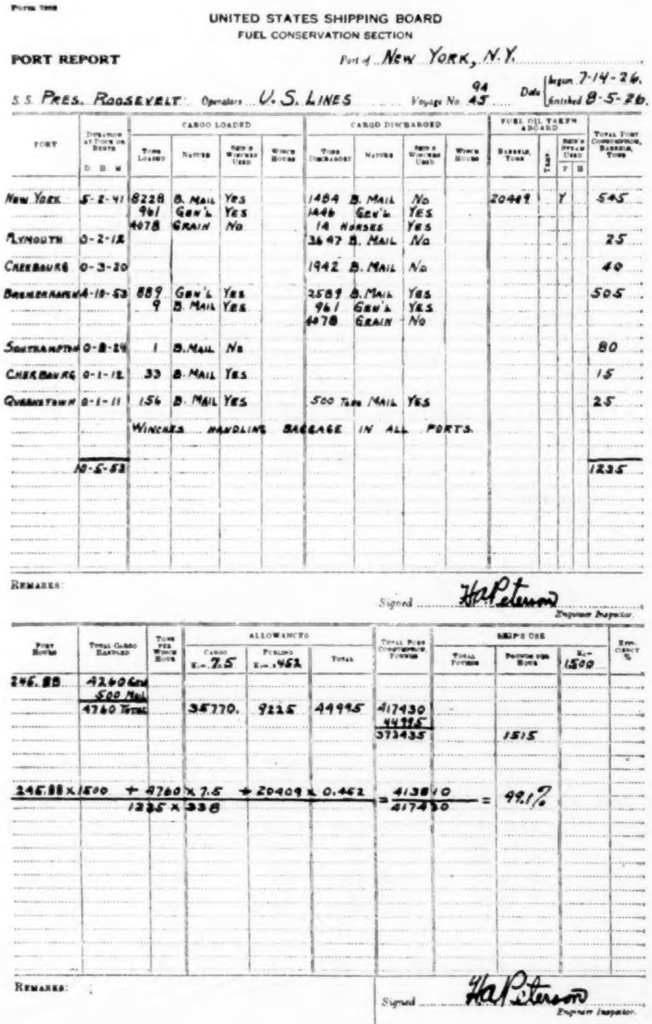
Fig. 10 shows the type of report used for determining the port efficiency. The work of developing port standards was especially assigned to the author and J. S. Malseed of the Fuel Conservation Section.

In regard to results obtained, Mr. Jefferson, in his paper on this subject given before the Society of Naval Architects and Marine Engineers, in 1924, stated:

The results that have been obtained from applying these methods are best demonstrated by a visit to the vessels themselves. An inspection of the engine department, a survey of their average work list, and a talk with the engineer officer will show today that, instead of these vessels being just a temporary means of livelihood for the great majority of officers, as was the case only a couple of years ago, they are now vital units of the American merchant marine, the physical condition and the performance of which are matters of considerable concern to the present operating personnel.

Improvement in Fuel Economy

A tabular comparison of the sea performance of the Hog Island vessels, for example, shows that in 1922 the performance of these vessels was divided as follows:


UNITED STATES SHIPPING BOARD
FUEL CONSERVATION SECTION

PORT REPORT Port of New York, N.Y.

S.S. Pres. Roosevelt Operators U.S. Lines Voyage No. 94 45 Date begun 7-14-26, finished 8-5-26.

Port	Duration at Dock or Berth D H M	Cargo Loaded: Tons Loaded	Nature	Ship's Winches Used	Winch Hours	Cargo Discharged: Tons Discharged	Nature	Ship's Winches Used	Winch Hours	Fuel Oil Taken Aboard: Barrels, Tons		Ship's Steam Used	Total Port Consumption, Barrels, Tons
New York	5-2-41	8228	B. Mail	Yes		1484	B. Mail	No		20409		Y	545
		961	Gen'l	Yes		1446	Gen'l	Yes					
		4078	Grain	No		14	Horses	Yes					
Plymouth	0-2-12					3647	B. Mail	No					25
Cherbourg	0-3-20					1942	B. Mail	No					40
Bremerhaven	4-19-53	889	Gen'l	Yes		2589	B. Mail	Yes					505
		9	B. Mail	Yes		961	Gen'l	Yes					
						4078	Grain	No					
Southampton	0-8-24	1	B. Mail	No									80
Cherbourg	0-1-12	33	B. Mail	Yes									15
Queenstown	0-1-11	156	B. Mail	Yes		500	Tons Mail	Yes					25
		Winches handling baggage in all ports.											
	10-5-53												1235

Remarks:

Signed H. A. Peterson Engineer Inspector.

Port Hours	Total Cargo Handled	Tons per Winch Hour	Allowances: Cargo K_1=7.5	Fueling K_2=.452	Total	Total Port Consumption, Pounds	Ship's Use: Total Pounds	Pounds per Hour	K_3=1500	Efficiency %
246.88	4260 Gen'l									
	500 Mail									
	4760 Total		35770.	9225	44995	417430				
						44995				
						372435		1515		

$$\frac{246.88 \times 1500 + 4760 \times 7.5 + 20409 \times 0.452}{1235 \times 338} = \frac{413810}{417430} = 99.1\%$$

Remarks:

Signed H. A. Peterson Engineer Inspector.

FIG. 10 PORT REPORT, UNITED STATES SHIPPING BOARD

2 vessels below 60 per cent rating
2 vessels between 60 and 70 per cent rating
20 vessels between 70 and 80 per cent rating
25 vessels between 80 and 90 per cent rating
17 vessels between 90 and 100 per cent rating
2 vessels slightly above the 100 per cent standard

while in 1924 the performance of these same vessels showed:

0 vessels below 70 per cent rating
4 vessels between 70 and 80 per cent rating
23 vessels between 80 and 90 per cent rating
27 vessels between 90 and 100 per cent rating
14 vessels slightly above the 100 per cent standard

This table also shows that the average sea-performance efficiency of this class had been brought from 83.7 per cent in 1922 up to 92.5 per cent in 1924, that the average speed had been increased 0.15 knot, while the daily consumption had been reduced 1.93

ton and the pounds-of-fuel-per-mile factor had been reduced 21 pounds.

As to port performance, the data show that, at the time port standards were put into effect in 1923, the performance of the vessels was divided as follows:

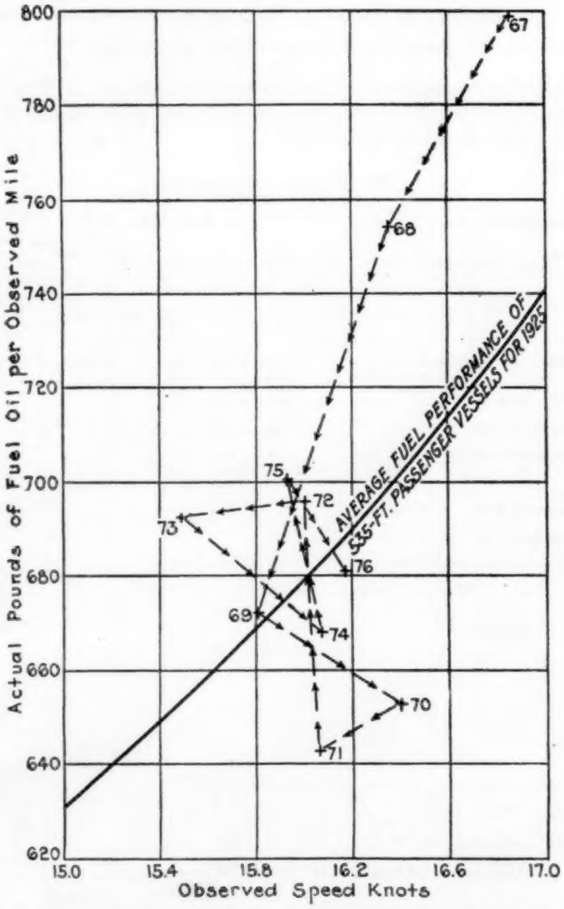


FIG. 11 FUEL PERFORMANCE CHART, *S. S. President Madison*

(Voyages plotted *below* smooth curve have fuel performances better than average of class; those plotted *above* have fuel consumption greater than average.)

Voyage No.	Started	Terminated	Voyage No.	Started	Terminated
67	10-11-24	11-30-24	72	8-31-25	10-20-25
68	12-10-24	1-28-24	73	10-30-25	12-19-25
69	3- 4-25	4-22-25	74	12-29-25	2-16-26
70	5- 3-25	6-22-25	75	2-27-26	4-17-26
71	7- 2-25	8-21-25	76	4-28-26	6-17-26

10 vessels below 50 per cent rating
20 vessels between 50 and 60 per cent rating
20 vessels between 60 and 70 per cent rating
10 vessels between 70 and 80 per cent rating
7 vessels between 80 and 90 per cent rating
1 vessel between 90 and 100 per cent rating

while the reports for the same vessels show the port performance standards to be (one year and a half later):

1 vessel below 50 per cent rating
11 vessels between 50 and 60 per cent rating
15 vessels between 60 and 70 per cent rating
24 vessels between 70 and 80 per cent rating
12 vessels between 80 and 90 per cent rating
5 vessels between 90 and 100 per cent rating

It will also be seen from this table that the average port performance efficiency had been brought up from 62.8 per cent to 72.6 per cent.

The total fuel used per hour in port had decreased from 560 lb. per hr. in 1923 to 495 lb. per hr. in 1925, or 65 lb. per hr. As the cargo handled had increased somewhat, the amount consumed for ship's use, after deducting the amount required for bunkering and handling cargo, is a better value to use for comparative purposes. This value was reduced from 471 lb. per hr. in 1923 to 396 lb. in 1925, or a saving of 75 lb. per hr. for ship's use.

The average mileage per year for one of these vessels is approximately 50,000 miles which means that the 80 vessels of this class travel a total of about 4,000,000 miles per year. With the pounds-of-fuel-per-mile factor reduced 21 lb. this represents a fuel reduction of 37,500 tons in sea consumption, which at the present cost of fuel represents approximately $400,000 per year.

The time spent at sea in traveling 50,000 miles at 10.43 knots amounts to 4794 hours, which leaves 3966 hr. in the year for time spent in pilot waters and in port. Approximately 8 per cent of this time is used in pilot waters, so that time actually spent in port duty is about 3600 hr. per year. As noted above, the fuel required for other than bunkering and cargo-handling purposes in port has been reduced 75 lb. per hr. This, therefore, represents a saving of 120.5 tons per year per vessel. For the fleet of the 80 vessels of this class, this becomes 9640 tons, which, at present fuel prices, represents approximately $102,000 per year.

The combined savings made in sea and port fuel consumption therefore makes a total fuel saving of over $500,000 for this one class of vessels.

The fuel consumed in 1922 less the fuel consumed in 1925 on the basis of the miles and port hours of 1925 shows a reduction of $2,500,000 in the fuel bill per year. The increment of increased savings is naturally decreasing but the first half of 1926 compared to the last half of 1925 shows a saving of $174,500.

With the standards for both sea and port conditions in full operation, their values checked by experience, and a spirit of competition developing among the various lines and between sister ships, it was only natural to find a ratio which would express the total sea and port performance of any ship. This was called the Combined Port and Sea Efficiency Rate, and is computed as

$$\frac{(\text{Port fuel} \times \text{Port rate}) + (\text{Sea fuel} \times \text{Sea rate})}{(\text{Port Fuel}) + (\text{Sea Fuel})}$$

so as to weight the combined value in terms of total fuel used for both purposes.

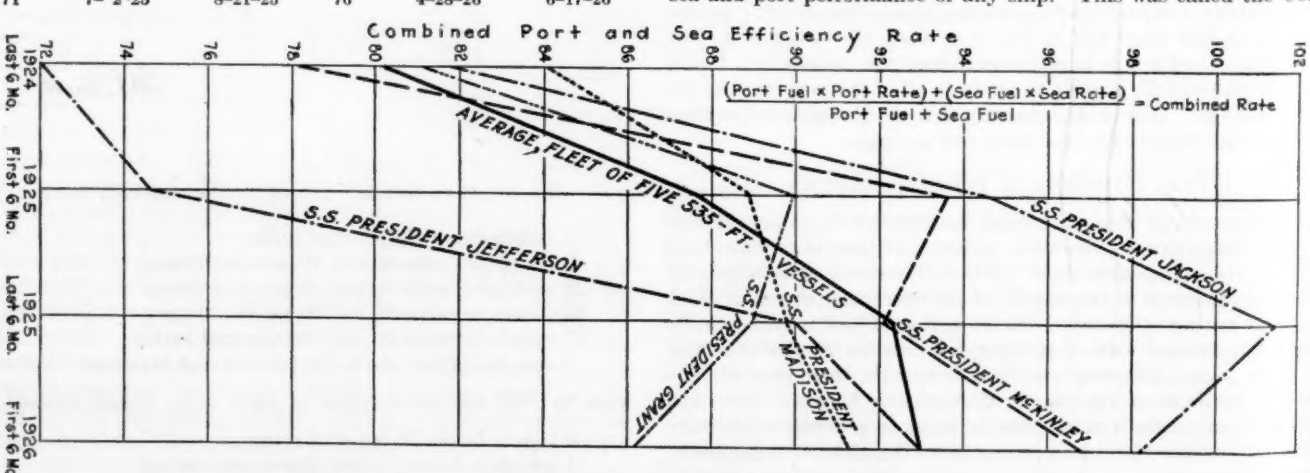


FIG. 12 COMBINED PORT AND SEA-EFFICIENCY RATES

For each class of ships there is also plotted a curve of the average sea performance of the class for the previous calendar year. The performance of each ship for each voyage is then plotted on this sheet so that a comparison is shown, not only from voyage to voyage, but also with sister ships. Fig. 11 shows such a record for one of the five President ships of the American Oriental Mail Line, operating out of Seattle, Washington. Fig. 12 shows a graph of the combined efficiency of these same ships. It is to be noted that the average of this fleet made a sharply progressive improvement during the first eighteen months of fuel conservation work, and quite naturally is flattening out at the present time. Fuel conservation work was first installed in the eastern ports, and experience gained there was of value in starting work on this fleet. This average curve serves as a good example of results obtained by application of fuel-conservation methods to a fleet of vessels.

Copies of the voyage and port reports are sent promptly to operators before the next sailing wherever possible, and are studied with a view of detecting any inefficiency in personnel or in equipment. A letter from the Fleet Corporation, United States Shipping Board, containing recommendations and comments, always accompanies each voyage and port report.

Fig. 13 illustrates a blank which was developed for filing purposes only in the section office, but which gives such a good synopsis of the ship's record that copies are often requested by operators and at the present time these are frequently consulted by those intending to purchase some of the government ships.

Colonel G. Bartlett, Operating Manager, Cosmopolitan Steamship Lines, states from the operators' point of view:

> Three copies of the voyage report are received by the operator, one is held in the office for office use, one is sent to the master of the ship, and the third to the chief engineer with such instructions as may be necessary in addition to the comments already contained in the report. The data on the office copy are transferred to a form which shows the comparison of the data with previous reports. At the bottom of this form two curves are plotted: one showing the efficiency for each passage, and the second showing the efficiency over all voyages to date. This latter curve is of value in showing at a glance any consistent gain or loss in efficiency. The same form is given to the chief engineer of the ship who is required to keep it up to date, getting whatever assistance may be necessary from the office.
>
> For each different type of ship, that is Federal, Hog Island A, etc., the efficiency-percentage-to-date curves are drawn on another form to the same set of coördinates. This form then shows clearly a comparison between ships of the same type. A study of the curves, together with a consideration of the different types of auxiliary equipment on the ships, and also the personnel, is of great benefit in locating the faults of those ships that show continued poor performance.
>
> The inauguration of the Shipping Board voyage reports on fuel conservation, together with the establishment of the fuel-oil school at Philadelphia, has resulted in a tremendous amount of interest among the operating personnel in burning oil efficiently, and has produced intense rivalry among the masters and the chief engineers, particularly on the same type of ship. The master and the chief engineer have access to all data in the office and frequently consult the figures, etc., of the other ships to see why the other ship is beating them out. The plan has also tended to promote coöperation between the master and the chief engineer, and the whole subject of fuel economy is brought more forcibly before the attention of the master and gives him additional incentive to see that a steady course is steered and that no fuel is wasted in steaming unnecessary distances.

The Fuel-Oil School

This coöperation on the ship combined with competition between ships is one of the valuable results of fuel-conservation work. In order to get the best results from this competition and to direct the efforts of the personnel towards such channels as will produce the most economic results it has been considered advisable that the engineers be given training in one of the most important phases affecting efficient operation, namely, boiler performance.

To this end, a fuel-oil school was established in October, 1922, through the courtesy of the United States Navy at the Philadelphia Navy Yard Fuel Oil Testing Plant, where a short, intensive course of instruction is given in the principles and practice of combustion and the methods of attacking the problem of boiler efficiency in a logical and intelligent manner so as to obtain maximum results.

The benefits derived from this training have been so satisfactory that in response to requests from West-coast operators a similar school was established at the Mare Island Navy Yard, San Francisco, in June, 1924. During the past four years approximately 1200 American merchant-marine engineer officers have attended these schools in addition to 150 commissioned officers in the United States Navy and the United States Coast Guard, who have taken advantage of this instruction.

The course is short but intensive, lasting five days as follows:

MONDAY

9–10	a.m.	Lecture on oil characteristics
10–11	a.m.	Lecture on curves
11–12	a.m.	Inspection of boiler plant
1–2.30	p.m.	Lecture on specific gravity; Baumé hydrometer viscosity, moisture and sediment, flash and fire point
2.30–4	p.m.	Demonstration in laboratory of above feature

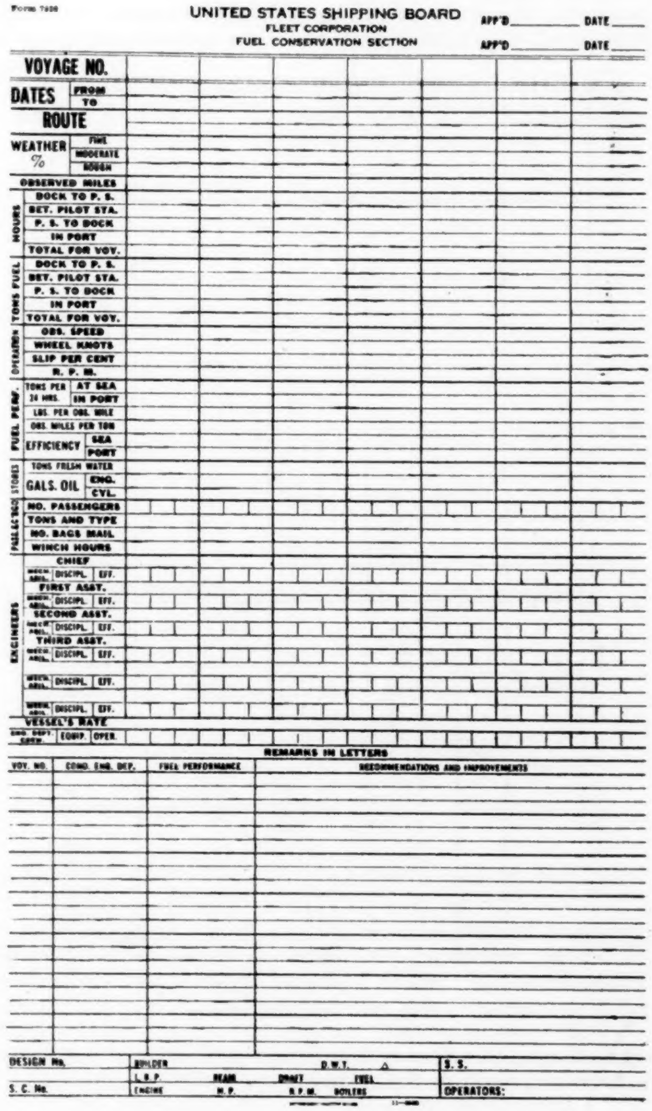


FIG. 13 SHIP'S RECORD BLANK

TUESDAY

9–10	a.m.	Safety precautions
10–12	a.m.	Lecture on combustion, Orsat, draft gage, pyrometer
1–4	p.m.	Laboratory operation of Orsat, draft-gage, pyrometer, interpretation of CO_2 curve and excess air

WEDNESDAY

9–10	a.m.	Lecture on atomization, cleaning tips, atomizer
10–12	a.m.	Demonstration of spray with tip-testing apparatus and in boilers
1–4	p.m.	Laboratory work. Regulation of flame colors, smoke and gas analysis

THURSDAY

9–12	a.m.	Lecture on refractories and insulations
1–4	p.m.	Laboratory work installing brickwork and plastic

FRIDAY

9–10	a.m.	Lecture on water-testing outfits and water treatment
10–12	a.m.	Laboratory use of water-testing outfits
1–2	p.m.	Summary lecture by Commanding Officer of Fuel-Oil School.

As these classes are conducted at the official Fuel Oil Test Plant of the United States Navy; the equipment includes boilers of various types including water-tube and Scotch boilers for the specific instruction of merchant-marine officers. The advantages of studying other boiler appurtenances and auxiliaries, as well as complete measuring instruments and devices, are evident. The school has, for example, a glass-enclosed burner-tip spray house in which numerous types of burners may be operated and the actual angles of spray and other characteristics of these burners may be observed.

Marine engineers who measure up to the school standards in completing the course are given a suitably engraved certificate. It is hoped that further work along post-graduate lines can be

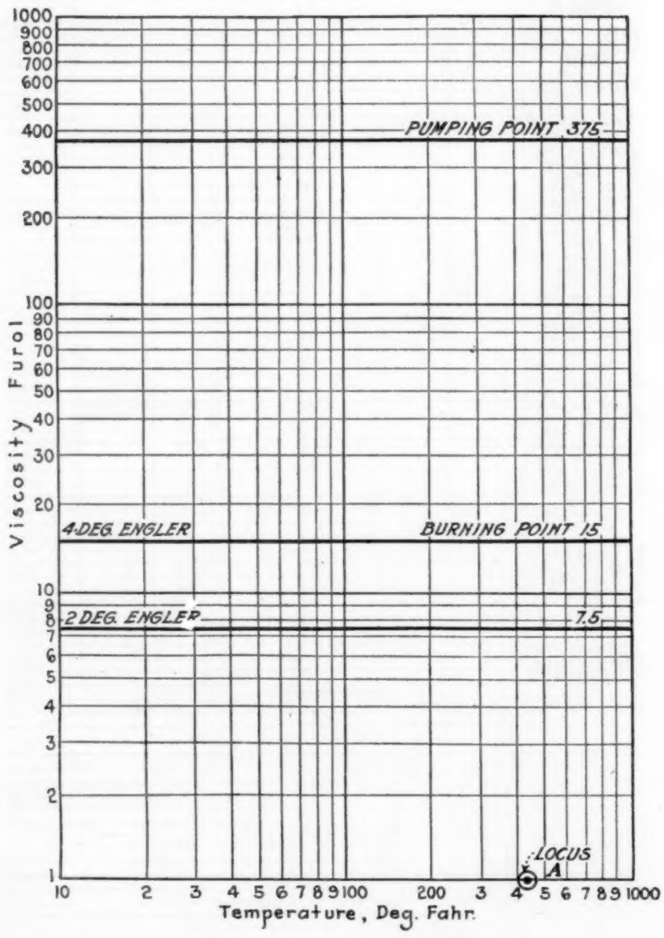


FIG. 14 VISCOSITY CHART

supplied soon, as well as certain regular publication of engineering material of interest to the graduates of the fuel-oil schools.

OPERATING PERSONNEL

The two factors which will affect the efficiency of operation are material and personnel, and, when once the ship has been built and is in service, the latter factor becomes by far the more important.

Comparison made on the basis of ratio of actual fuel performance of those given by the standards for any particular class of vessels in our fleet bring out the difference in results obtained on vessels fitted with the identical equipment but manned by crews of varying grades of personal efficiency. This is one of the greatest values of the standards, as it so often shows plainly which are the better-manned vessels.

However, care must be taken in passing judgment on the personnel efficiency based on this ratio alone, as foulness of bottom, weather conditions, inferior grade of fuel, hidden defects in equipment, or some other factor beyond control of the operating personnel may cause a poor performance. When such a performance is shown, careful analysis of voyage reports must be made to determine just where the trouble lies.

It has been our experience, in about 85 per cent of the cases, that the trouble lies with the operating personnel, and our greatest efforts have been directed towards pointing out where waste exists which the operating personnel itself must correct.

TESTING OF NEW DEVICES

The fuel-oil schools under the direction of the Fuel Conservation Section act as coördinators between the various Government agencies for the improvement of marine-engineering practice. New devices appearing to have engineering merit can be tested there under nearly sea-going conditions.

In a recent report Mr. Jefferson mentions some of the results of this work from which the following summary is taken:

> Some changes have been made in the equipment of ships to facilitate better operation, such as substitution of natural-draft oil-burner registers in lieu of the combined coal and oil fronts with which so many of our vessels were fitted out during the period of war construction.
>
> The combined coal and oil natural-draft front can be made to function satisfactorily, but, with the air regulation by means of ashpit and fire doors, it is difficult to maintain a high combustion efficiency under varying atmospheric conditions. To eliminate this difficulty, natural-draft registers having a readily adjustable air admission, which permits close regulation of air for combustion, have been installed.
>
> The combined coal and oil fronts operating under forced draft, such as the Howden system, have not been changed, as we have not found sufficient improvement in economy to justify it.
>
> The rigid connections between oil supply lines and burners have been replaced by flexible connections, so that regulation of burner setting can be effected to take care of variance in spray angle, caused by slight wearing of tips and atomizing chambers, and also by changes in draft conditions.
>
> A uniform type of burner ring installation has been adopted. It is V-shaped periphery type which gives a more intimate mixture of atomized fuel with the air necessary for combustion, as the cone of atomized oil can easily be brought to an approximate point of tangency with this burner-ring opening, and the incoming air is directed at approximately right angles to the atomized oil.
>
> Smoke detectors have been installed, which consist simply of a beam of light thrown across the last pass of the gases and reflected by mirrors similar to a periscope installation, so as to be visible from the floor plates, the intensity of this light being such that, with a smoke-free breeching, the reflected light disk will be bright yellow, and with No. 1 Ringelmann smoke the light will be cut off entirely. Between these two extremes, wisps of smoke will cut across the path of the light beam, producing a pulsating effect on the light disk. This will indicate from 0.25 to 0.5 Ringelmann smoke. By checking the conditions noted with the flue-gas analysis, it is determined at just what rate of pulsation the best combustion is produced. We have found this simple apparatus to be one of the most satisfactory guides for combustion control.
>
> Use of the viscosimeter for the predetermination of temperature required for obtaining the viscosity at which the fuel oil can be pumped and atomized, resulted in the elimination of the cut-and-try methods which the operating personnel would otherwise have to follow in determining these values.
>
> One determination of the viscosity of the oil on hand may be made and the corresponding point plotted on the chart shown in Fig. 14. This point is connected by a straight line to point *A*. Point *A* is located from the observation that all of our fuel oils when heated to a temperature of 430 deg. fahr. reach one second Saybolt. Logarithmic scales on the chart transform the usual exponential viscosity curve into a straight line. The chart then readily gives to the engineer an indication of the best pumping and atomizing temperatures at which to adjust the oil heaters.
>
> In the case of coal burners, grates have been modified so that the full length of fire can be easily worked and thereby prevent the air holes in the rear end of the fuel bed so common on the former excessively long grate bars. This has resulted in an increased rate of fuel per square foot of grate surface, but it has been found that so long as this rate is kept down to 30 lb. per sq. ft. per hr., the draft condition on our vessels is satisfactory for efficient combustion.
>
> Rear-end soot blowers, which reduce the labor required for maintaining clean fire surfaces, have been installed with resultant double effect: (1) they keep the tubes clean, and (2) they show up leaky smokebox connections which would interfere with the draft and so affect the efficiency of combustion.
>
> Cast-iron ventilated bridgewalls have replaced the old-time brick bridgewalls, which were broken down after the first few cleanings in endeavoring to break loose the clinker from them.
>
> Vacuum condition on the turbine-driven vessels has been given special attention, one of the corrective measures being the installation of bifurcated connection from air pump to condenser shell so as to give a connection to both sides of the tube support sheet. Another corrective measure is the utilization of excess auxiliary exhaust for heating purposes, which not only effects an improved thermal efficiency but also reduces the load on the condenser.

From the above outline of the chief changes that have been made in the equipment, it will be seen that they are of a more or less minor nature, and, of course, all of them never apply to one vessel. All are along the line of accepted engineering practice and have demonstrated that they will pay for themselves in a short time by improved economy of operation.

The general response made by the operating engineers to the efforts made by the Fuel Conservation Section in securing better performance has been so gratifying that the committee devised a system of publishing semi-annually an honor roll of ships whereon the fifty best performers are announced. To the chief engineers of each ship on the honor roll is awarded a cash bonus of fifty dollars. The captains of these ships also receive a similar bonus in case the other departments of the ship are in as satisfactory condition as the engineering department. A supplementary list of ships constitute an honorable-mention roll.

In order that a ship be considered by the committee as a candidate for the honor roll, her record must show her to have traveled at least 20,000 miles during the previous six months' period, must have a combined port and sea rating equal to 95 per cent of the leading ship of the class, and must have a minimum combined rate of 90 per cent for herself. The physical condition of the departments, maintenance charges, and disciplinary records are also considered in determining honor-roll ships.

Effect of Bottom Condition

Standard curves such as Fig. 8 for all classes of ships have been in operation for a sufficient length of time to establish their essential accuracy and trustworthiness for average conditions. They still leave something to be desired however in making it possible to separate the effect of bottom condition of the ship from current effect when checking up the observed speed, speed corresponding to the power apparently developed, and the wheel speed. It is also difficult to make a proper mathematical allowance for varied weather conditions on a single passage for which the horsepower developed is being computed.

E. V. David of the Fuel Conservation Section has devised an application of the Dyson method of propeller analysis and of trial-trip data which bids fair to solve this problem. The intricate nature of this work does not admit of its presentation here but would make it a proper subject for some future paper before the Society.

Pulverized-Coal Research

During the past year tests have been in progress at the Fuel Oil Testing Plant at the Philadelphia Navy Yard under the direction of the Fuel Conservation Committee in an attempt to develop apparatus and methods of burning pulverized coal at sea. A Scotch boiler has been under test and these tests give promise of developing some very practical and economical methods of steam generation using the cheapest fuels. Burners which produce the necessarily short flame and which permit as much as 96,000 B.t.u. per cu. ft. of furnace volume liberated per hour are now under test. Three important industrial firms are coöperating in these tests. The United States Navy, while not primarily interested in the use of pulverized fuel for its fleet, has been very coöperative and has rendered invaluable assistance in both a technical and advisory capacity.

Economy of operation with pulverized coal is assured but it is hoped that the mechanical difficulties which would interfere with regular and reliable operation at sea as well as with manœuverability can be overcome. When ships can be sent to sea with pulverized-coal-burning apparatus of proved reliability another noteworthy contribution by American engineers in the reduction of fuel costs will have been made.

Diesel Engines

When Congress appropriated $25,000,000 for the use of the Shipping Board in carrying out its program of Dieselizing a certain number of cargo vessels the Committee forwarded, in November, 1924, through regular channels, its hearty concurrence in the plan and urged that the program be started with a maximum effort as promptly as possible. Certain types of Diesel engines had proved themselves in the medium and smaller sizes but there was considerable development work to be done in constructing these in sizes of around 3000 b.hp. If these larger sizes could be developed and built promptly, they could replace some of the existing steam plants and the resulting saving in fuel would begin soon enough to help pay for any engines contracted for in the near future. There would soon be a group of several steam ships which could be advantageously Dieselized because of reboilering, overhauling, or other extensive maintenance work. These would be fit subjects for determining how much greater revenue-earning power and decreased operating costs would result from the transformation to Diesel power plants.

The public press in November, 1924, carried detailed accounts of the awarding of contracts for eighteen Diesel engines of approximately 3000 b.hp. each, some double acting, but the majority to be single acting. At a later date bids were received for the auxiliaries and installation work in the ships upon delivery of the main engines. As dependability and manœuverability are prime requisites in these engines, very severe shop tests are required of each builder.

The Shipping Board has the double responsibility of fostering all possible development work which will be of benefit to the

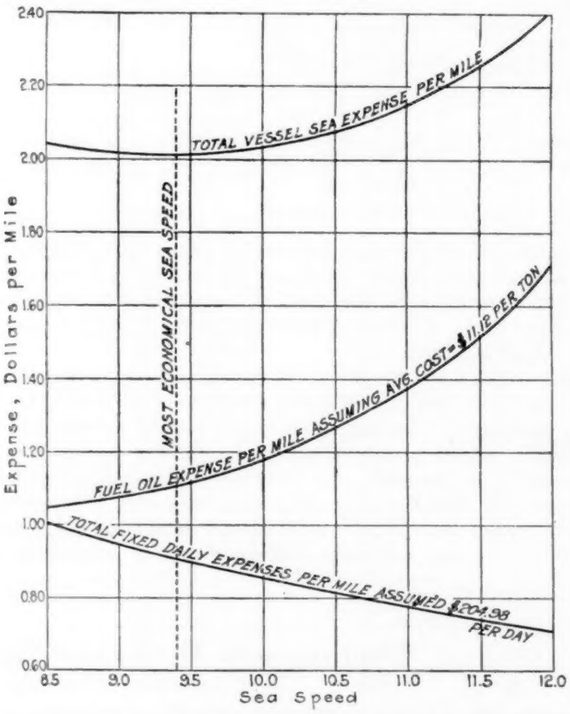


Fig. 15 Total Vessel Sea Operating Expense, per Mile, Hog Island A Ship

American merchant marine and at the same time of producing a substantial reduction in the costs of ship operation, while it is the operator of such a large shipping business. The development work on the Diesel program has naturally taken considerable valuable time but is now making very acceptable progress.

The sale of government vessels has been proceeding successfully under the terms of the Jones act and there now remain but 274 vessels in the government fleet on 26 lines with 20 operators. The Shipping Board has sold over 1000 vessels which are now being operated by privately owned companies, not including the vessels sold for scrapping. After two of the government lines were sold, the new owners requested the Fuel Conservation Section to continue its inspections and reports as in the past. The Government was justified in continuing this service because of its large equity in the property. In the case of a third line, the purchaser has organized a fuel-conservation section of his own, which has been patterned after that of the Fleet Corporation organization described in this paper.

Total Operating Costs

The cost of fuel is but one-third of the total operating cost of a vessel and it is natural to analyze the total operating costs by the same engineering methods which have been so successfully applied to fuel conservation. The number of variable items which enter into total operating cost make the problem of establishing standards still more complicated.

Considering all items as either revenue or expense, a classification may be made as follows:

Revenue

- 1 Cargo
- 2 Passenger
- 3 Mail
- 4 Miscellaneous

Expense

Direct Expenses

- 1 Cargo
  - *a* Stevedoring
  - *b* Other cargo expense
- 2 Passenger expense
  - *a* At sea
  - *b* In port
- 3 Mail expense

Indirect Expenses

- 4 Operating expense
  - *a* Vessel
    - 1 At sea
    - 2 In port
  - *b* Miscellaneous
- 5 Port expense
- 6 Overhead expense

The total operating expense at sea per mile depends on the speed. The cost of crews' wages, meals, etc., is constant per day and independent of speed, while the cost of fuel per day increases rapidly with the speed. Table 5 shows an analysis of this one item for a Hog Island A ship.

These same data presented in graphical form in Fig. 15 with ordinates of dollars per mile and abscissas of sea speed show the usual characteristics when an operating and an overhead cost are graphically added to give a curve of total sea operating expense which has a minimum point at the most economical sea speed. It was assumed that the only daily operating cost which increased with the speed was the fuel cost. Repair costs have not proved to be greater per day with increased speed and are considered to be

TABLE 5 VESSEL OPERATING EXPENSE PER DAY HOG ISLAND A SHIP

Fixed Daily Expenses per Day

Wages, deck	$ 52.18
Wages, engine	50.20
Wages, stewards	14.20
Meals, crew	18.00
Water	1.00
Stores	14.00
Equipment, deck, engine, and stewards	8.40
Repairs, deck, engine and stewards	42.00
Miscellaneous	5.00
Total	$204.98

Vessell Operating Expense, Port

Total fixed daily expenses	$204.98
Total fuel per 24 hr. at $11.12 per ton	48.21
Total	$253.19

Vessel Operating Expense, Sea

Speed, knots	9.0	9.5	10.0	10.5	11.0	11.5
Miles per ton	10.37	9.95	9.42	8.79	8.11	7.34
Pounds per mile	216.0	225.2	238.0	255.0	276.3	305.1
Miles per day	216.	228.	240.	252.	264.	276.
Tons per 24 hr.	20.83	22.92	25.47	28.68	32.57	37.61
Cost per day at $11.12 per ton	$231.70	$254.80	$283.20	$318.80	$362.20	$418.20
Cost fuel per mile	1.073	1.118	1.180	1.265	1.372	1.515
Fixed expense per mile	0.949	0.899	0.855	0.813	0.777	0.743
Total expense per mile	2.022	2.017	2.035	2.078	2.149	2.258

a function of the efficiency of engineers rather than of operating sea speed. This has been noticeably true for this type of ship with the present operators.

As operating data are accumulated much more intelligent thought can be applied to the problem of setting standards for the other items connected with revenue and expense. The operator is not always able to secure the most profitable cargo in the correct amount and operate the vessel with the minimum number of days' stay in port as shown by an analysis of the characteristics of the vessel and its cargo carrying capacity. It is confidently expected that the application of this analytical method of studying the performance of the ship as a whole in terms of dollars as well as B.t.u., of cargo secured and handled, of turn around days, or fixed expenses and other costs, may lead to a type of efficiency rating which, when fairly applied, will show a gratifying approach to the ideal in all items affecting the cost of operating ships.

Preliminary Report of the Federal Oil Conservation Board

The discussions before the Federal Oil Conservation Board were reported in Mechanical Engineering, March, 1926, p. 289. In connection with its preliminary report now made to President Coolidge, Secretary Work calls attention to conflicting views among the producers, some of them fearing the field of production is limited and others believing that there will be sufficient supplies for a long period by the adoption of proper conservation methods.

The Board expresses concern over future supply of oil, because of the manifest dependence of so large a part of our industrial life, national defense and domestic comfort upon continued adequate supplies of lubricants for all machinery and fuel for automotive engines. The total present reserves in pumping and flowing wells in the proved sands has been estimated at about 4,500,000,000 barrels, which is theoretically but six years' supply, though, of course, it cannot be extracted so quickly. Therefore future maintenance of even current supplies implies the constant discovery of new fields and the drilling of new wells. Hitherto there has been no failure to discover such new fields as required.

The waste of gas from oil fields is enormous and represents a triple waste as it involves the loss of large quantities of casinghead gasoline with a fuel value of gas itself, and reduction of oil recovery from the sands due to loss of pressure.

On the other hand, certain favorable factors are also pointed out. Deeper drilling has added greatly to the supply. Furthermore, some leading authorities consider that less than one-sixth of the oil is now recovered. During recent years a considerable amount of investigation and experimentation has been made with different methods of forcing out the content oil with water, air or gas pressure, either directly from the surface or through the proposed method of sinking shafts and driving galleries underground. Some of the authorities on these methods believe that a second crop from known sands can be obtained as great as that already recovered and available in the proved reserves.

Among the recommendations made one that will raise most discussion is that pertaining to the so-called unit pull operation.

The common right of adjoining owners to reduce to possession respective oil and gas in the pools tapped by wells drilled on their lands should involve some recognition of correlated obligations so that in the drawing of oil and gas by one owner from the common reservoir the producer should be required to recognize the right of the neighbor to so much of the oil as is withdrawn from underneath his property, after proper allowance for the cost of production, the hazard of the undertaking, and a reasonable profit on the undertaking.

The right of the state police powers to prevent the action of one owner from working a deprivation of the rights of other owners of a common property and to prevent waste or destruction of the common property by one of the owners seems reasonably clear.

The right of the state to prevent the waste of natural resources is rendered more important in this matter by the newly discovered or at least more widely recognized facts regarding the role of gas in the oil sands.

The authority of the state to prevent the waste of natural gas has already been declared and it logically applies as well to the dissipation of gas pressure, without which great quantities of oil would be entirely wasted. Geologic science and engineering practice as well as economic considerations of waste afford a broad foundation on which to base state legislation.

If the several oil-producing states should protect property rights in oil produced from a common underground supply it undoubtedly would have some effect in the direction of stabilizing production. (*New York Herald-Tribune*, Sept. 6, 1926.)

The Cotton Textile Industry

A Broad Economic Analysis of the Problems of the Industry Both North and South, Dealing with Cotton Consumption, Output, Hours of Operation, Wages and Efficiency of Operatives, Exports and Imports, Cost of Manufacture, Conditions Adversely Affecting Industry in Recent Past, Remedies Available, Etc.

By CHARLES T. MAIN[1] and FRANK M. GUNBY,[2] BOSTON, MASS.

THE Chairman of the Textile Division of the Society has requested the authors to prepare a paper on the broad economic problems of the cotton mills in the South.

The cotton-mill industry is one of the oldest and one of the most widely distributed industries in the country. Its problems in one section of the country are so intimately related to those in other sections that the authors have decided to consider the industry as a whole for the purposes of this paper.

They have endeavored to show some of the important data for the whole industry and then to show the division between the mills in the cotton-growing states and those in the non-cotton-growing states.

Most of the statistical data used were collected by the Bureau of the Census and have been published by the National Association of Cotton Manufacturers.

Historical Outline

It is less than two hundred years ago that inventions which are responsible for the great changes in methods of production were begun, and it is only a little over one hundred years ago that the power loom was perfected.

From 1775 to 1790 several Englishmen familiar with the cotton industry and machines used at that time came to America and manufactured goods in a small way. After 1790 power looms were introduced and small mills were built. In 1815 the first mill was built by Francis C. Lowell, at Waltham, Mass., in which all the processes involved were carried on.

The progress of the business of cotton manufacturing was thereafter continuous in the northern states, but in the South there was a greater fluctuation. By 1850 the industry in the South had progressed to a point where the effect of southern competition was being given serious consideration by the northern mills. Soon after that the Civil War occurred and the industry in the South was destroyed, and it was not until 1880 to 1890 that its present growth began. Since 1890 its growth has been rapid and continuous.

In the northern states the industry as a whole was prosperous from the time it started until about 1920. Since then, while individual mills have been prosperous, the majority have not been.

In rehabilitating her cotton mills, the South was largely dependent upon capital from the North. On the whole, her mills were only fairly successful, and many were unsuccessful, up to 1914. From 1914 until 1921, everyone owning a few spindles, North or South, could make a profit, and during this period most of the southern mills, and the South as a whole, got established on a firm financial basis.

When the great demand for goods dropped off in 1921, it was discovered that the southern mills were able to lower wages and operating costs well below the peak during the war, and that the northern mills could not reduce wages nearly so much. This difference produced a serious handicap for the northern mills.

Competition of the southern mills, however, is not the only thing which has caused such disaster in the industry during the past two years, but it is an important factor, and one which will last for some time to come. No one can tell how long the differential in favor of the South will last, or if it will ever be wholly eliminated.

There are some fundamental economic conditions that probably cannot be eliminated. So long as the supply of native-born labor in the South is equal to the demand, and the cost of living in that section lags behind the cost of living in the North, just so long will the South have an advantage. Transportation of raw materials will be less in many places. The cost of power will be less in most places. So long as the cost of labor is less, the cost of construction will be less.

There are other advantages that may prove to be only temporary.

During this present period of depression the southern mills have also suffered losses, but nowhere near the extent of those in the northern mills. The other branches of the textile industry have also suffered.

The total number of spindles in the world has increased from about 103,100,000 in 1900 to 166,000,000 in 1925, an increase of about 61 per cent. Great Britain has about 60,000,000 spindles, the United States about 38,000,000 spindles, France and Germany approximately 10,000,000 spindles each, India 8,000,000, Italy 4,600,000, Japan 4,500,000, and China 3,600,000.

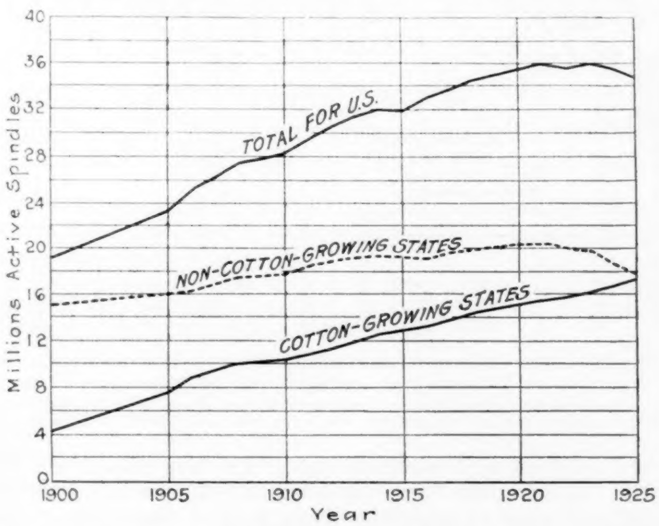


Fig. 1 Active Spinning Spindles in the United States—1900–1925

(Figures to nearest 100,000.)

Year	Non-cotton-growing states	Cotton-growing states	Total
1900	15,100,000	4,400,000	19,500,000
1905	16,000,000	7,600,000	23,700,000
1910	17,800,000	10,500,000	28,300,000
1915	19,000,000	13,000,000	32,000,000
1920	20,300,000	15,200,000	35,500,000
1921	20,300,000	15,700,000	36,000,000
1922	19,800,000	15,900,000	35,700,000
1923	20,000,000	16,300,000	36,300,000
1924	18,900,000	16,900,000	35,800,000
1925	17,700,000	17,300,000	35,000,000

Growth of the Industry North and South

From 1900 to 1925 the active spindles in the North increased from 15,100,000 to about 20,300,000, an increase of 5,200,000, or 35 per cent. During the same period the active spindles of the South increased from 4,400,000 to 17,300,000, an increase of 12,900,000, or 293 per cent. The present indications are that there will be no increase but rather a decrease in the North, as some mills will liquidate and as many mills have already moved or are considering moving machinery South, or are making any increases in capacity in the South, while the southern interests on their own account are building additional mills.

The active spindles in the southern states for the year 1925 were 17,300,000 and in northern states 17,700,000, which was a decrease from the maximum for the North of about 2,600,000

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active spindles since 1921, while the South had increased its active spindles by about 1,600,000 spindles during the same period.

In 1925 there was a total of about 37,900,000 spindles installed in the country, of which about 2,900,000 were not operated at all during the year.

The chart Fig. 1 shows the active spindles by years since 1900 for the whole country and for the cotton- and non-cotton-growing states. The flattening out of the curve of active spindles in recent years is significant.

Hours of Operation

The number of spindles North and South are now nearly equal, and the indications are they will be equal within a short time. But this is not so serious as the number of hours the spindles are run.

The laws of Massachusetts have fixed a 48-hour week and pro-

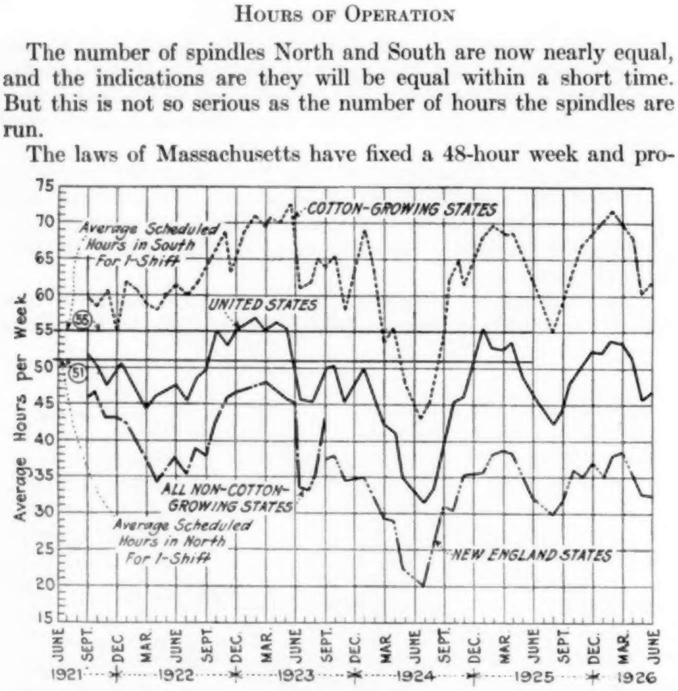


Fig. 2 Graph Showing the Average Number of Hours Each Cotton Spindle in Place in the United States Operated per Week

(Based on data issued by the Department of Agriculture, U. S. Bureau of the Census, in monthly letters entitled Activity in the Cotton-Spinning Industry.)

hibit the working of women at night. The laws of the rest of the New England states have established a 54-hour week. Attempts are being made in some other states in New England to reduce the hours to 48.

The legal working hours in the southern states for one shift vary from 54 to 66, but there is a general understanding and custom of running 55 hours a week for one shift. Many mills are run with two shifts, 110 hours a week.

The effect of these laws and customs of operation is that the full legal running time in Massachusetts is about 200 hours a month. The actual hours run in the two sections were about as follows:

1922—North 170 hours, South 250, or 47 per cent more than the North
1923—North 180 hours, South 280, or 60 per cent more than the North
1924—North 137 hours, South 246, or 80 per cent more than the North
1925—North 144 hours, South 264, or 85 per cent more than the North

Fig. 2 shows the average number of hours run per week by all the spindles installed. The southern mills have averaged to run each spindle installed about 3100 hours per year, while the northern mills have averaged only about 1900 hours per year.

Consumption of Cotton in Bales

Fig. 3 shows the number of running bales of cotton used per year by the mills of the country since 1900.

In 1922 the northern mills used 2,570,000 bales and the southern mills 3,978,000, or a ratio of 1 to 1.46.

In 1923 these figures were: North, 2,822,000; and South, 4,489,000; or 1 to 1.59.

In 1924 they were: North, 2,165,000; South, 4,050,000; or, 1 to 1.87.

In 1925 they were: North, 2,392,000; South, 4,460,000; or 1 to 1.87.

A portion of the smaller consumption of the northern mills is due to the finer average size of yarn made in the North.

The above shows that the South has the bulk of the business so far as pounds go, and the result of all the factors is that when the country is not consuming the product of all the mills at full capacity the South will get what is termed in power-plant parlance "the base or steady load," and the North will get the "peaks." Every one knows that periodical and peak loads are not profitable ones to carry.

It is interesting to note that the line of consumption of cotton has been moving approximately horizontally for the past several years, and also that during the past two or three years, during which the cotton-manufacturing industry has been suffering financially, the volume of the cotton consumed was exceeded only during the war years and during 1923. In 1923 the industry was prosperous.

Wages and Efficiency of Operatives

The most important element in any manufacturing enterprise which requires a considerable amount of labor in proportion to the other factors, is that there shall be an abundant supply of intelligent people who are willing to work for a reasonable return, and who will be reasonably contented. This is a condition which now prevails in the South.

The wage scales in the southern states vary from 25 to 40 per

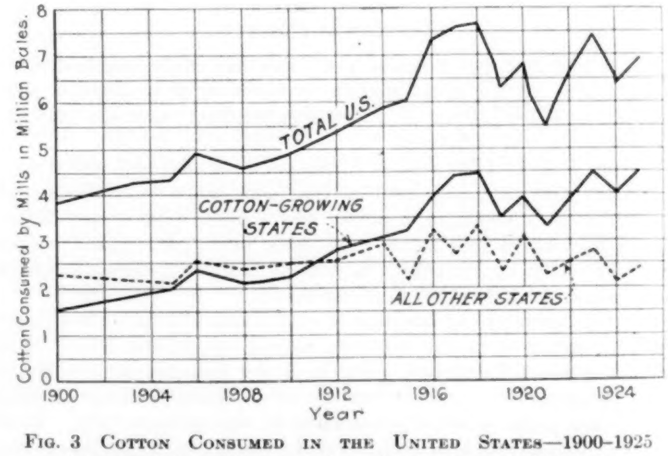


Fig. 3 Cotton Consumed in the United States—1900–1925

(Running bales used per year by mills—to nearest 1000 bales.)

Year	Non-cotton-growing states	Cotton-growing states	Total
1900	2,350,000	1,523,000	3,873,000
1905	2,139,000	2,140,000	4,279,000
1910	2,507,000	2,292,000	4,799,000
1915	2,816,000	3,193,000	6,009,000
1920	3,048,000	3,714,000	6,762,000
1921	2,257,000	3,152,000	5,409,000
1922	2,571,000	3,978,000	6,549,000
1923	2,823,000	4,489,000	7,312,000
1924	2,166,000	4,051,000	6,217,000
1925	2,392,000	4,460,000	6,852,000

cent less than in the North, the larger difference being further South.

The operatives are all native whites, most of whom have lived in the mountains and have been accustomed to hardship and privation. They know they are better off in the mill towns than they were before. Most of these towns have good schools and some social attractions, and they think they are better off in the manufacturing center with the attractions of a modern city. They all speak the English language and understand what is said to them. They are interested in their work and in the welfare of the mills. They are fully as intelligent and efficient as similar workers in the North.

More stress is placed on the words "skilled labor" than is warranted. It does not take long to teach an intelligent person to run the ordinary machines in a mill, and most of the immigrants coming into the northern mills have to be taught also. It is easier to teach a native southerner than a southern European.

Colored help are used in the South only in the picker room, boiler house, and dyehouse, where they are separated from the whites.

In the North, some of the mills in the country towns still have

a considerable proportion of their help who speak English, but the great majority of the operatives are foreigners, or of foreign descent, and do not speak our language. Much good work is being done in their Americanization and in teaching them the language.

This lack of a common language, and widely divergent views on economic problems which have been imported from foreign lands, are two of the serious handicaps of the industry in the North.

The Supply of Operatives

There is an ample potential supply of operatives, outside of the Carolinas, to run as many more spindles as there are now in the South. All that is necessary to obtain them is to build mills, with their villages in most cases. At the higher elevations the climate is almost ideal.

Climate, however, is a thing which we talk about a good deal. Each community seems to like its own climate as much as we do our New England climate.

Table 1 shows the population and spindles in the various cotton-growing states.

TABLE 1 NUMBER OF COTTON SPINDLES PER PERSON IN COTTON-GROWING STATES, BASED ON DATA FROM UNITED STATES BUREAU OF CENSUS ESTIMATES FOR THE YEAR 1925

State	Population	Spindles	Spindles per person
Virginia	2,449,000	694,000	0.300
North Carolina	2,759,000	5,909,000	2.310
South Carolina	1,779,000	5,295,000	3.150
Georgia	3,058,000	2,807,000	0.972
Alabama	2,467,000	1,471,000	0.627
Tennessee	2,425,000	468,000	0.200
Mississippi	1,790,000	142,000	0.080
Kentucky	2,488,000	93,000	0.039
Louisiana	1,879,000	96,000	0.054
Texas	5,098,000	225,000	0.047
Total	26,192,000	17,200,000	
Average			0.655
Average of first six states			1.110
Average for last four states			0.048

If all of the first six states could operate as many spindles as South Carolina without importing foreign labor, they could run more than 40 million spindles; on the basis of North Carolina they could run more than 30 million spindles.

About twice as many spindles could be run as now, omitting Mississippi, Kentucky, Louisiana, and Texas.

The people of Tennessee and Texas are particularly active in trying to locate mills in their states. At two spindles per operative they would support several million spindles.

Massachusetts has about 12,000,000 spindles in place and a population of 3,852,356 in 1920, or a little over three spindles per person, or about the same as South Carolina.

Management

New England does have the advantage of skilled management, based on many years of experience, and for this reason may possibly turn out a better grade of product, as a rule, at slightly less cost, other things being equal.

If labor conditions could be evened up between the North and the South, the northern manufacturers could overcome the other adverse factors.

Kinds of Goods Manufactured

The woven goods made in this country amounted to approximately $6^1/_3$ billion square yards in 1919, $6^3/_4$ billion in 1921, and $8^1/_4$ billion in 1923.

The sales yarns made were 618 million pounds in 1919, 484 million in 1921, and 620 million in 1923.

Nearly all of the mills of the South are making medium or coarse goods and yarns, and only about 10 per cent of their product might be designated as fine goods. In the North a greater proportion, probably one-third, of the product is fine goods.

In the year 1923 the southern mills made about two-thirds of all the medium- and coarse-goods cloths and nearly three-quarters of all the pounds of sales yarn.

Competition is largely on the coarser grades, but there is no reason why the finer grades cannot be produced in the South. The chief reason why they have not been made in a greater proportion is because they can make a good profit in normal times on staple medium and coarse goods, and therefore there has been little inducement for going into fine work, which requires greater care and caution on the part of management, with a capacity for forecasting styles, getting on to them early, and getting off in time to dispose of the goods before the styles have changed.

Exports and Imports

In 1915 our exports of cotton goods amounted to nearly $100,000,000. This increased to over $400,000,000 by 1920. In 1921 the exports dropped to about $120,000,000, and in 1922, 1923, and 1924 were about $140,000,000.

The imports of cotton goods in 1915 amounted to about $40,000,000 and with the exception of 1920, when they amounted to $137,000,000, increased gradually each year, amounting in 1923 to $100,000,000. In 1924 they were about $90,000,000, and in 1925, $80,000,000.

It has been said that imports of fine goods have recently been equal to the product of all of the New Bedford mills.

Table 2 shows the exports and imports of the principal types of goods in recent years in terms of quantity. Only those items are shown for which the quantities could be so expressed in the Government reports.

TABLE 2 EXPORTS AND IMPORTS OF COTTON GOODS BY QUANTITY

Item	1915	1917	1919	1921	1923	1924	1925
Exports							
Cloth of all kinds, in millions of running yards	518	747	683	552	..	..	..
Cloth of all kinds, in millions of square yards	..	..	..	..	464	479	543
Yarn, in millions of pounds	?	?	21	14	12	14	22
Hosiery, in millions of dozen pairs	?	?	10	3	5	5	6
Imports							
Cloth of all kinds, in millions of square yards	43	?	50	106	219	177	109
Yarn (except thread) in millions of pounds	6	?	4	3	5	4	4
Hosiery, in millions of dozen pairs	0.8	?	0.1	0.7	0.6	0.5	0.6

It will be noted that the number of square yards of cloth imported has decreased since the high point in 1923, so that the figure for 1925 was about the same as it was in 1921.

The number of yards of cloth exported in 1925 was about the same as in 1921, and has been exceeded only during the war and boom years following.

The imports of yarn are small and have held practically constant, while the exports of yarn have increased so that during 1925 they were practically as large as they have ever been.

Total Goods Manufactured or Used in the United States

Table 3 shows the amounts of the principal types of goods manufactured in the United States, combined with the imports and exports, all expressed in units of quantity. For the years 1919, 1921, and 1923 the Bureau of the Census gives statistics as to the amount of goods of the various types made by the mills in this country. The results are shown in this table. A similar census is being made up for 1925, but the results are not yet available.

TABLE 3 GOODS MANUFACTURED OR USED IN THE UNITED STATES

Item	1915	1917	1919	1921	1923	1924	1925
Cotton Cloth in Millions of Square Yards							
Manufactured in U. S.	...	...	6317	6704	8264	...	...
Imported	43	?	50	106	219	177	109
Total	...	...	6367	6810	8483	...	...
Exported	518[1]	747[1]	683[1]	552	464	479	543
Used in Country	...	...	5684	6258	8019	...	...
Yarn in Millions of Pounds							
Manufactured in U. S.	...	...	618	484	621	...	...
Imported	6	...	4	3	5	4	4
Total	...	...	622	487	626		
Exported	?	?	21	14	12	14	22
Used in U. S.	...	...	601	473	614	...	...

[1] These figures are in running yards.

This table shows that there were about 40 per cent more yards of cloth used in the country in 1923 than in 1919, while the amount of sales yarn used was about the same as in 1919.

Judging from the amount of cotton consumed and from the spindle-hours run, the amount of cloth used in the country in

1925 was about 25 per cent greater than it was in 1919, and perhaps 10 per cent less than in 1923.

Fig. 4 shows diagrammatically the relation of the cloths made in this country and the imports and exports.

These figures seem to refute the idea often advanced that the trouble with the cotton-mill industry is that the use of cotton goods has fallen off to a large extent.

Relative Factors North and South

As has been shown, the southern mills run their spindles more hours per year than the northern mills. The result of this is that the South gets the base, or steady, load of the business and the northern mills take the peaks, and are obliged to curtail first whenever there is not business enough for all.

The southern mills can operate more cheaply than the northern mills, and can undersell them. Perhaps if the southern mill

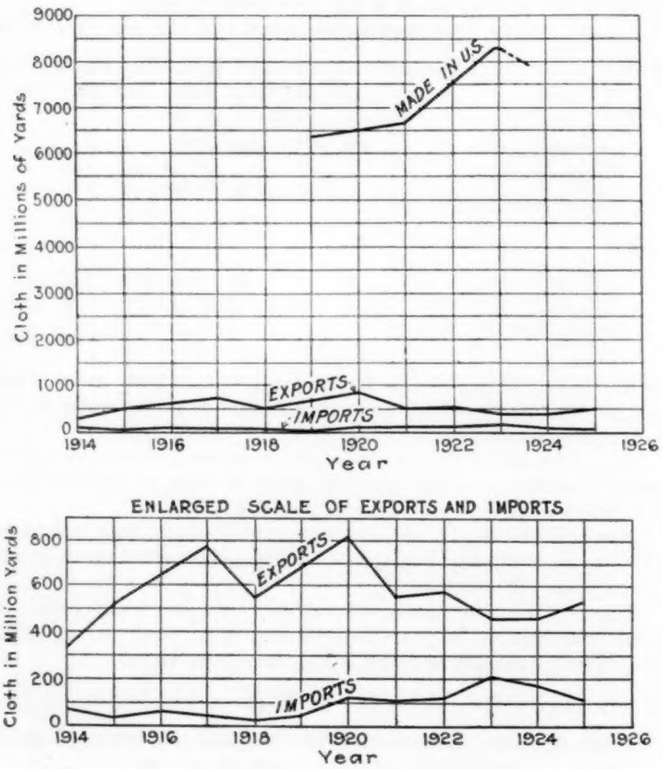


Fig. 4 Cotton Cloth Manufactured in the United States and Imported and Exported

men clearly realized the conditions they would undersell their northern competitors only slightly and allow the northerner to make some profit on the orders he gets, instead of underselling him so far that they themselves are experiencing difficulties from the effects of competition among themselves.

The great advantage that the southern mills have over their northern competition is in the item of labor cost. The other factors are minor ones, but are talked about the most. These factors are:

Transportation. The cost of raw materials, including transportation on raw materials and finished goods, amounts to about 2 per cent in favor of the South.

If goods are sent north for finishing and then shipped to the purchaser, there is very little difference in the total cost of transportation. Finishing plants are being erected in the South, so that this excess cost of freight will be, in part at least, eliminated.

Power. There is much talk about cheap power. This is not a vital factor in textile manufacturing, as the cost of power in a plain mill is only about 5 per cent of the total cost of the product. In colored mills, where warm water and low-pressure steam are required in the finishing processes, the heat of the power plant, which would otherwise be wasted, can be used, thus reducing the net cost of power for manufacturing purposes.

With the great development of the natural water resources of the South, of which there are many, power can be and is sold there for about two-thirds of what it costs in the North. A saving of one-third means a difference of less than 2 per cent in the cost of the product.

The idea that industries will go to a place because power is relatively cheap there is fallacious, so far as the textile industry is concerned, as the item of labor far outweighs that of power. Paper and pulp mills, using large amounts of power in proportion to labor, do seek locations where power is cheap.

Overhead. Fixed overhead is an item which must be met in any place. The items entering into it are depreciation, taxes, insurance, repairs and maintenance, administration, and sales.

As the cost of construction is about 20 per cent less in the South than in the North, there is a little saving in depreciation.

Taxes vary in different localities, but there is a marked difference between the high taxes prevailing in the North and the relatively low taxes of the South.

A tax of 75 cents a spindle is not uncommon in the North as against 50 cents a spindle in the South, thus showing a saving of one-third in taxes for the southern mill.

Repairs and maintenance are less in the South, as labor is less.

Comparison of Cost of Manufacturing North and South

In order to make an approximate estimate of the difference in cost of manufacturing North and South, we have assumed the reproduction cost of a medium-goods mill in the North to be $50 per spindle, and in the South $45 per spindle, and that the cost per year of the product of a spindle for the northern mill would be $40.

We have also assumed that the management is equally good North and South.

Table 4 shows the cost for the northern mill running 48 hours per week and a southern mill 55 hours. This table shows that of the total difference of $6.73 per spindle per year, $4.53, or two-thirds of it, is in the single item of labor.

Another interesting fact is that the difference in cost of producing the same goods between the northern and southern mills is sufficient to pay a good rate of dividend on the capital of the southern mills.

There are sections of the South where the savings in labor over the northern costs would be somewhat greater, and sections where it would be smaller than shown here.

TABLE 4 COMPARISON OF COST OF MANUFACTURING NORTH AND SOUTH

			Mass. mill on 48-hr. week		Southern mill on 55-hr. week		
			Per cent of total	Cost	Per cent saving	Cost	Saving in dollars
1	Materials, including transportation of raw and finished goods		45	$18.00	2	$17.64	$ 0.36
2	Labor for mill		34	13.60	33	9.07	4.53
3	Power		5	2.00	33	1.33	0.67
4	Supplies		2	0.80	0	0.80	0.00
5	Fixed charges:	Per cent					
	(a) Average depreciation	3.1		1.24	10	1.12	0.12
	(b) Taxes	2.0		0.80	33	0.77	0.03
	(c) All insurance	0.6		0.24	0	0.24	0.00
	(d) Repairs and maintenance	2.5		1.00	25	0.75	0.25
	(e) Administration and sales	5.8		2.32	0	2.32	0.00
	(f) Total fixed charges	14.0	14	5.60		5.20	....
	Total		100	$40.00		$34.04	$ 5.96
	(g) Saving in fixed charges due to running 55 hr. instead of 48 hr.				14	−0.77	+0.77
	Comparable southern mill, cost and saving					$33.27	$ 6.73

$6.73 + $40 = 16.8 per cent less cost in South than in North.

Effect of Mill Village

This difference in favor of the southern mill is usually reduced somewhat if it maintains a larger mill village than the northern mill, the average for a full village as against no village being about 5 per cent on the cost of the goods. As against a Massachusetts mill which maintained a portion of a village, the saving of the southern mill might be reduced by about 2 per cent on the cost of the goods.

Net Difference

It will be conservative to say that there is a difference of at least 14 per cent, or $5.60 less cost for the product of each spindle in favor of the southern mill.

Effect of Varying Hours of Operation

Fig. 5 shows the effect on the cost per pound of goods of operating a mill a different number of hours per week. This curve is based on making a type of goods which would cost about 61 cents per pound when made in a Massachusetts mill operating 48 hours per week.

It is not the same mill as assumed in Table 4, and is inserted merely to show the relative variation in cost North and South under different hours of operation. It was prepared at a time when cotton and goods prices were much higher than they are now.

Other Conditions Which Have Affected the Industry Adversely During the Recent Past

Depression in the cotton textile industry has not been confined to this country. It has been disastrous in England, due principally to the fact that her colonies have not been buying. They also made a mistake in increasing the capitalization of their mills when the industry was booming.

In this country, losses have not been confined to the North, but the losses in the South have been nowhere as severe.

Some of the chief reasons for the general financial depression in the industry have been the high prices and large variation in price of cotton, the increase in imports of cotton cloths, and the fact that increase in exports has not kept pace with the increase in spindles in this country. Probably the greatest reason is

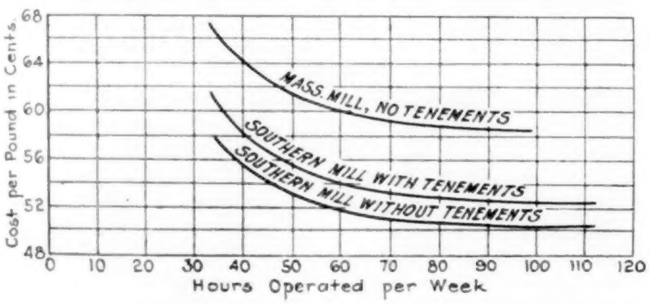


Fig. 5 Effect of Varying Hours of Operation—Cost of Goods per Pound (11 Per Cent Overhead) on 48-Hr. Basis

Notes.—Based on fabric costing, with all charges except profit, $0.611 per lb. for Massachusetts mill when running 48 hr. per week, with fixed charges figured in this cost at 11 per cent of total.

Southern labor taken as 67 per cent of Massachusetts when reduced to 48-hr. basis (Ala. actual rate = 55 per cent; S. C. = 60 per cent) without cost of operating tenements. Cost of operating a full set of tenements taken as 20 per cent of the southern payroll.

that the increase in spindles coupled with the practice of running mills more than one shift, which is particularly prevalent in the South, has caused the production to increase faster than the demands of the market.

The effect of high-priced cotton, the variation in price of cotton, and the surplus of finished goods is that the buyers have refused to pay a price based on the price of cotton which would yield a fair profit to the manufacturer. The prospects of a fairly fixed price is of as much importance as a moderate price. With a high price jobbers are always anticipating a drop, which in turn would affect the cost of goods, and they and the retailers will buy only from hand to mouth.

The large crops of cotton from 1911 to 1915 caused the price of cotton to drop in 1915 to 10.6 cents high and 7.25 cents low, and in 1916, to 13.45 cents high and 9.20 cents low. These prices were too low for the cotton grower to realize a profit. Then came the effect of war requirements, and prices rose in 1916–1917 to 27.65 high and as high as 43.75 in 1920. Then the price dropped in 1923 to 23.75. The short crops of 1922 and 1923 then caused the prices to rise to what was generally termed as 30-cent cotton, and buyers refused to purchase goods at a fair price based on 30-cent cotton, and a tremendous depression occurred in the business—northern mills were run on short time or shut down, resulting in great losses to many.

This period was followed by the large crops of 1924 and 1925, and an expected large crop for 1926, which has resulted in lowering the price of cotton to around 17 cents to 18 cents with talk of still lower prices, which has again greatly disturbed the market, as well as causing serious concern to the cotton farmers. In the recent months there have been few orders for cotton goods.

Fig. 6 shows the variation in price of cotton and size of crops since 1900.

Silk Products

In an article and an editorial in the Boston *Transcript* of May 15, 1925, concerning the convention of the Associated Knit Underwear Manufacturers of America, it was stated that 2,500,000 men in this country now wear silk underwear, or about one in every twenty, and that about one-half the women do the same. We are unable to vouch for this statement, but it is evident that most women wear silk stockings. This is the cause of the liquidation

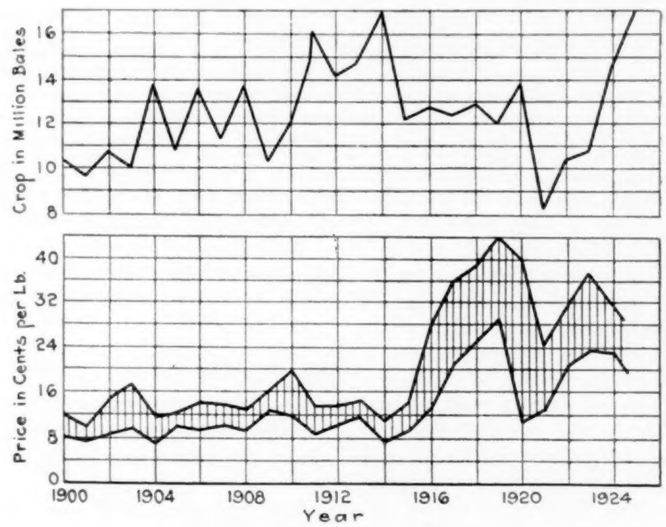


Fig. 6 Variation in Cotton Crop and Prices Since 1900

(Crop includes linters.)

Year	Crop in bales	—Prices in Cents per Lb.— Middling High	Low
1900	10,266,000	12.00	8.10
1905	10,805,000	12.60	9.85
1910	12,006,000	19.75	12.30
1915	12,123,000	13.45	9.20
1920	13,880,000	40.00	10.85
1921	8,351,000	23.75	12.80
1922	10,370,000	31.30	20.35
1923	10,808,000	37.65	23.50
1924	14,500,000	31.80	23.41
1925	17,100,000		

of the Lawrence Manufacturing Company, Lowell, Mass., which has been making cotton underwear and hosiery.

The silk industry has been running at capacity. The "rayon" or artificial-silk industry is going strong. Although the poundage of these fabrics is small in comparison to that of cotton goods, it cannot be doubted that the expansion in these lines has some effect upon the market for cotton fabrics.

The amount of rayon used in this country in 1925 was only about 55,000,000 lb., and the amount of silk imported was about 64,000,000 lb.

History Repeats Itself

It will be interesting to read an extract from a book entitled The American Cotton Spinner, by Robert H. Baird, published in Boston in 1854.

> The comparative idleness of our cotton factories is, no doubt, a lamentable prospect; but it would be unjust to charge this result to the general Government and the tariff alone. The advance in the price of the raw material, consequent upon the rapidly increasing demand, and the partial failure of the crops, has as much a tendency to produce this effect, as the policy of the Government; a high tariff would not have prevented the partial stoppage of our factories.
>
> From Rhode Island, that busy cotton-cloth-making hive, we learn that about seventy factories have stopped; from Lowell and our eastern manufacturing villages, we hear the same ominous reports. In Maryland, in the Patapsco Valley, "silence reigns," and even from the sunny South we hear of depression and suspension of manufacturing operations. From east, west, north, and south, "the times are bad," the cotton manufacturers say, and they say so truly. The important question in such case is, "What is the cause?" One says "A higher tariff is wanted;" another says it is owing to the high price of cotton, and a few among the great many say "it is owing to manu-

facturing too many coarse goods." The first question is a political one and we therefore will not discuss it. The other two are so entwined together that we must and readily can establish their truth or falsity. If the demand for cotton cloth was equal to the supply, the high price of cotton would be paid by the consumer. There is every reason to believe that the supply has been greater than the demand, for the coarse-cotton manufacturers of Britain have long been in a depressed state, the exports being less for the last two quarters in every kind of cotton manufacture; and taking this into consideration, along with the great number of our factories which have done but little for the past six months, we should have expected some clearance in threads in the markets, and a respectable advance in the prices, to meet the corresponding high price of cotton; but no such appearance of demand for goods is manifested, or rather the markets are as glut-full of cheap goods as ever. The merchants always like to sell cheap; they care not for the manufacturer's interest, only give them cheap goods to sell. It is a commercial fact, too, that "when prices are once lowered to a fixed standard for some time, it is almost impossible to elevate them above it, however great the necessity may be for doing so." It is our opinion that there have been too many of our factories engaged in making coarse cotton goods. At the North this is self-evident, for coarse goods can be manufactured cheaper at the South, and with the great number of factories now in operation in Georgia, Alabama, Tennessee, South Carolina, and some other states, how can it be expected that our northern manufacturers can long keep the field against them—they cannot do it. Leaving the political question out of sight, there is one remedy which we would suggest, that is to go into the manufacture of finer fabrics, give your cotton more labor, employ more skill, and spend more for fine machinery. If you do not take our advice, there is a brave chance for you to lose all your machinery, factories and all.

The Civil War came, and conditions were changed.

Much of this advice given seventy years ago seems to apply well to the present situation.

Increase of Spindles and Population

From 1900 to 1925 the population of the United States, based on the estimates of the Bureau of the Census, increased about 50 per cent. During the same period, the active spindles in the country increased about 85 per cent.

The number of active spindles has held practically constant since 1920. During this period many new mills have been built, but the effect seems to have been that old spindles became inactive as new ones were added.

In July, 1921, the Bureau of the Census started collecting data each month as to the number of spindle-hours run by the mills of the country. For the year 1921–1922 the figure was about 89 billion, for 1922–1923, when the industry had a period of prosperity, it was 102 billion. For 1923–1924 it was 84, and 1924–1925, 91 billion. Based on eleven months' figures, it will be something over 86 billion for the year ending July 31, 1926. This is shown graphically in Fig. 7.

The apparent lesson to draw from this chart is that under recent conditions of marketing in this country, and considering imports and exports, we have more manufacturing capacity than can be kept busy all the time. The greatest factor which brings this about is that during the war years many mills operated two shifts where formerly nearly all the mills ran only one shift. Since the war some northern mills and many southern mills have continued to operate two shifts, and this has greatly increased the production capacity.

The productive capacity is now so far in excess of the market demand that there is little profit in the business for anybody engaged in it.

What Is the Remedy?

Before any remedy can be applied, the facts must be faced and acknowledged.

The aspects of the problem may be different from the standpoints of the northern and the southern mills, but much more progress can be made by coöperation than by each section going along independent of the other until they meet in competition in a glutted market. Neither section can solve this problem alone.

The primary trouble with the cotton mills at present is that the production is too large and the price of their products is too low.

From the standpoint of the industry as a whole, some steps should be taken to get prices on a profitable basis and keep them there. A program of curtailment would seem to be the immediate method of bringing this about. Such a program should be based on a careful study to establish what the requirements really are. Curtailment, however, can be regarded as only an immediate move to correct the present market condition.

Beneficial work can doubtless be done toward causing an increase in the use of cotton goods and an increase in our exports, and perhaps a decrease in imports.

The consuming public is demanding more attractive and artistic goods. This demand must be met and is now being developed.

The formation of the Cotton Textile Institute, the membership of which consists of mills engaged in cotton manufacturing and the object of which is to promote the progress and development of the cotton industry in the United States, should be of great benefit to the industry through the collection of authentic data

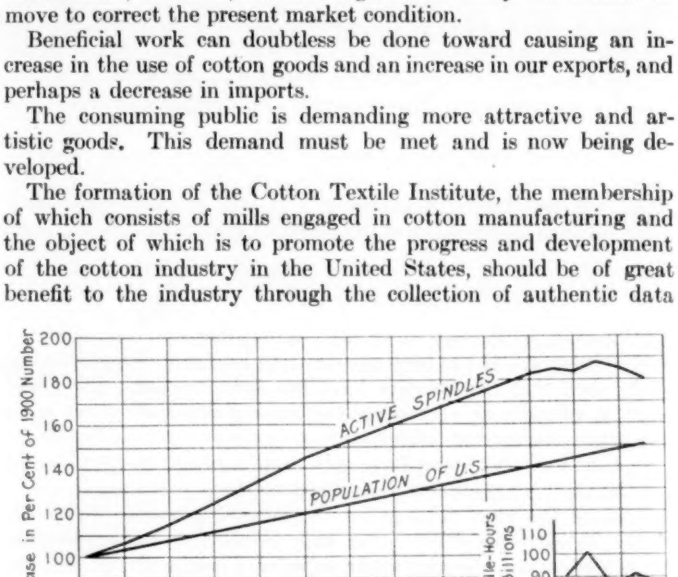


Fig. 7 Increase in Population and in Number of Active Spindles Since 1900

Year	Active spindles	Population	Spindle-hours
1900	19,500,000	76,000,000	....
1905	23,700,000	....	....
1910	28,300,000	92,000,000	....
1915	32,000,000	....	....
1920	35,500,000	106,400,000	....
1921	36,000,000	107,800,000	....
1922	35,700,000	109,200,000	89,308,000,000
1923	36,300,000	110,700,000	101,931,000,000
1924	35,800,000	112,100,000	84,359,000,000
1925	35,000,000	113,500,000	91,054,000,000
1926	....	....	86,151,000,000[1]

[1] One month estimated.

for the industry as a whole and by establishing a closer contact and coöperation between the various cotton-manufacturing organizations.

As there are about 1700 cotton mills in the country, grouped under about one-half as many financial organizations, representing an investment of several billion dollars, it will be seen that the problems of coördination are numerous and intricate.

The difference between the cost of manufacturing, North and South, is a problem applying particularly to the North.

Many suggestions have been made toward an equalization of costs. Some progress toward equalization will be made, but the differences cannot be wholly eliminated, and during the process some mills will, of necessity, liquidate.

We shall not attempt to enumerate possible methods the use of which might tend toward an adjustment. These will be brought out by the discussions of the Textile Institute better than we can state them.

As far as the condition of the North compared with that of the South is concerned, it appears to be one of those economic changes that occasionally occur which bring disaster to some who are so located as to be unable to compete with others who are more favorably located, considering all the factors of production.

A point which has apparently received little consideration in discussing the matter of over-production in the wool-manufacturing industry, is the effect which a change in the character of fabric produced might have upon the operation of machinery in this division. It would not take a very great change toward higher pick work to make necessary the employment of considerably more machinery. According to one authority an increase to sixty pick work, among those mills capable of producing this character of goods, would take care of a great many additional looms. This would reduce the element of excessive productive capacity to a very marked degree. (*Textile World*, Aug. 14, 1926, p. 47.)

Circular Saws—Their Cutting on Various Woods

History of the Saw Blade—Process of Manufacture—Experimental Cutting on Hardwoods and Softwoods—Cross-Cutting—Ripping—Mitering—General Discussion

By J. A. McKeage,[1] Montrose, Pa.

A SAW OPERATOR knows from long experience that with his saw blade in ordinary good condition and operating under ordinary good speeds, he will be able to cut off a piece of hardwood and expect to see a reasonably smooth surface, while a cut across basswood, pine, hemlock, or overdried hardwood will yield a flaky, pitted finish which is far from satisfactory, and which entails hard labor to put into condition for finishing. He also knows that a cut-off saw will continue to operate long after its teeth are worn, but the minute the set or edge to his rip saw indicates wear it is necessary for him to shut down and change saws or continue and operate at the expense of ever-increasing power and danger of burning his blade. No satisfactory explanation has yet been offered for this varied action of saw blades in different woods, nor, so far as the author has been able to determine, has any treatise been published or data made available which pertain to the actual cutting operations of cross-cutting, ripping, and mitering. Therefore the object of this paper is to determine by a system of experiments with various feeds, speeds, and types of blades, some definite law governing the cutting on various woods.

Scope of Experiments

In order to determine just what factors govern the action of circular saw blades on ordinary common woods, all types of blades were tried on the following: Ash, oak, hard maple, soft maple, cherry, beech, chestnut, white pine, yellow pine, basswood, and hemlock. While all the commercial woods are not represented in this list, it contains at least one or two whose grain resembles so closely any of those omitted that a definite law found should apply to all. Cuts were made at fast feeds and slow feeds, both on an ordinary belt-driven machine and on one equipped with a high-speed electrically driven saw blade. An analysis of the resulting surfaces, when greatly magnified, brought out a set of definite laws pertaining to the speeds, feeds, and type of teeth to be used. It was also revealed that a law governing the actual cutting behavior of a blade in any particular hardwood also applied to all other hardwoods; and, that a similar law for one softwood applied to all other softwoods; so for clarity and brevity in this paper, all the woods herein discussed will be classified under the headings of either "hardwoods" or "softwoods." Under the hardwoods may be included such woods as cherry, beech, birch, ash, maple, oak, and chestnut. Softwoods will include pine, basswood, hemlock, and whitewood. There are times and conditions that would justify the classification of chestnut, cherry, whitewood, maple, etc., as "semi-soft" or "soft," as, for instance, when maple is overdried. However, for the present discussion they will be kept under their respective headings.

The Manufacture of Saw Blades

The modern saw, like every other type of specialized tool, is a development and not a sudden discovery. The ruins of ancient Greece and Egypt have proved this by producing primitive serrated implements evidently used for sawing operations. At first, jawbones of animals and fish were used; and later, jagged flint was fashioned into crude saws. With the coming into use of copper and iron a great advance was made; and just prior to the advent of the circular saw all timbers not hand-hewn were sawn from the log by long blades resembling the present day "cross-cut" saw so familiar to the average farmhand and backwoodsman.

With the invention and patenting of the circular saw blade by Samuel Miller of England in 1777, a revolution in all sawing was instituted. His first circular blade consisted of an iron disk to the periphery of which were attached cutting teeth, but this form was later modified by the present saw in which the teeth are an integral part of the blade. Such strides have been taken in recent years that it is now possible to rip wood so uniformly and smoothly that the surfaces thus cut may be glued together in a perfect slab, this being heretofore possible only by careful jointing.

Originally, saws were made from such steel as might be available for the purpose, but as the art of steel refining progressed, the art of saw making kept pace, until today saw steel is made to an analysis which will permit of (1) hardening in large or small thin sheets without danger of breakage; (2) tempering to permit the teeth to be bent sideways and "set," and allow sharpening with an ordinary file; and (3) holding a good cutting edge under severe demands.

The development of speed and power for driving saws, together with the demands for faster and better cutting, has forced the saw manufacturer to employ only the finest grades of crucible steel, these being alloyed with such elements as may impart the necessary characteristics to meet certain demands. Without going into details as to the composition of the early blades, it may be said that the modern blade possesses a typical analysis approximately as follows:

	Per cent		Per cent
Carbon	0.75 to 0.85	Phosphorus	0.02
Manganese	0.25 to 0.35	Chromium	0.30 to 0.40
Silicon	0.20	Vanadium	0.15 to 0.20
Sulphur	0.02		

Nickel is sometimes used in lieu of vanadium, it being present in quantities of from 0.75 to 1.25 per cent. The remainder of the above analysis is pure iron.

The process of manufacturing blades has also undergone rapid changes, although the fundamentals have remained the same throughout. Briefly, this process may be outlined as follows:[2]

> From the rolled sheets circles are sheared. A center hole is punched slightly undersize. The punched blank is then placed on a centering pin on a press properly equipped with punch and die for cutting the teeth. Usually the press is equipped with an index for spacing the teeth properly and equally. After toothing, the teeth are hammered or rolled flat, all burr removed, and the saw is then ready to heat-treat. This operation is accomplished in an open gas-, oil-, or coal-fired furnace maintained at even temperature, and the heat regulated by pyrometers or other accurate heat-regulating devices.
>
> The saw is heated to the correct heat, predetermined by accurate knowledge arrived at in the laboratory of the actual critical heat range or recalescence point of the particular analysis or steel mix being treated. When the blade has reached the proper heat it is quickly withdrawn from the furnace and quenched in oil to thoroughly harden the steel. This process renders the steel glass-hard. It is then tempered by another heating process. In ordinary practice hardening is brought about by heating to 1460 to 1500 deg. fahr. and plunging in oil. Temper drawing is done at various temperatures from 450 to 800 deg., or even 900 deg. The higher this heat, of course, the softer the resulting saw.
>
> The blade is then allowed to cool and is straightened on an anvil with a suitable hammer. The process of hammering includes the process of imparting to the saw adequate adjustment of tension to enable the saw to operate at a given speed without waving at the rim, or laying over the collars. High speeds expand the rim of the saw by centrifugal force, hence a saw hammered for high speeds must have its rim shorter than its body. In other words, a high-speed saw must be baggy in the body to allow for rim expansion caused by centrifugal force of speed and by natural heat on the rim for cutting friction.
>
> After hammering, the saw is ground on the sides to bring it to an even thickness and balance. It is then polished. Last but not least, the teeth are filed and properly set.

In a saw of even thickness from hole in center to the rim it is necessary to provide clearance for the body in order to prevent undue heating from friction. This is done by bending the teeth or "setting" them over alternately right and left as in Fig. 4,

---

[1] Secretary and Chief Engineer, Beach Manufacturing Company, Assoc-Mem. A.S.M.E.

Contributed by the Wood Industries Division for presentation at the Old Dominion Meeting of the A.S.M.E., Richmond, Va., September 27–30, 1926.

[2] The author is indebted to Mr. H. C. Atkins, president of E. C. Atkins & Company, Indianapolis, Ind., for this outline of saw manufacture, also for data pertaining to saw-steel analysis and other related points.

or by swaging them out at their points. If it is desired that there be no "set" to the teeth, it is necessary to "hollow-grind" the body of the blade under the thickness of the rim as in Fig. 4.

There are hundreds of different types of these saw blades, carrying various trade names, but they might all be classified roughly under three headings: rip saws, cut-off saws, and variety (or miter) saws (see Figs. 1, 2, and 3). In order that the characteristics of these different types may be understood and explained, they

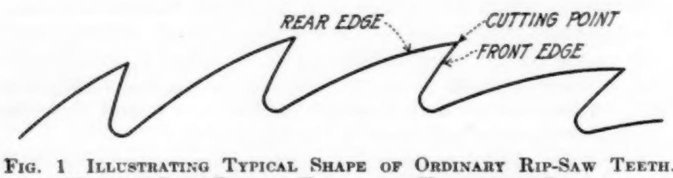


FIG. 1 ILLUSTRATING TYPICAL SHAPE OF ORDINARY RIP-SAW TEETH. NOTE THE LONG RAKE ON TOP AND THE UNDERCUT OF BOTTOM

FIG. 2 SHOWING TEETH OF CROSS-CUT BLADE. ONLY SLIGHT RAKE ON TOP. SOME CROSS-CUT TEETH HAVE RADIAL FLANKS ON FORWARD SIDE INSTEAD OF AS SHOWN

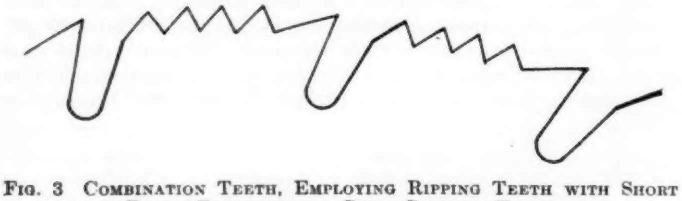
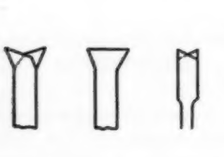


FIG. 3 COMBINATION TEETH, EMPLOYING RIPPING TEETH WITH SHORT RAKE, FOLLOWED BY CROSS-CUTTING TEETH



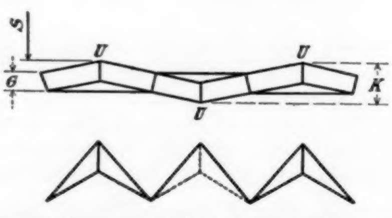


FIG. 4 (LEFT) SHOWING METHODS OF PROVIDING CLEARANCE FOR BODY OF BLADE. FROM LEFT TO RIGHT IS THE ORDINARY SET, SWAGE SET, AND HOLLOW-GROUND BLADE WITH NO SET

FIG. 5 (RIGHT) SHOWING APPROXIMATE SHAPE OF ORDINARY CUT-OFF TEETH. FRONT AND REAR EDGES OF TEETH FILED AT SHARP ANGLE TO BODY OF BLADE

will be discussed under their respective operating headings. However, before going into details of these cutting operations and their varied characteristics, it is better to explain an evil, applicable to sawing on all woods, which is a common cause of unsatisfactory cut surfaces and which is in no way influenced within reasonable limits by various saw speeds, feeds, etc.

THE COMMON CAUSE OF ROUGH CUT SURFACES

Referring to Fig. 5, which is an enlarged view of a typical set of cross-cut teeth, the thickness G of the blade is called the gage of the saw. The "set" of the tooth is equal to the distance S from the surface of the body of the blade to the extreme cutting point. The total amount of wood removed during a cut is equal to the dimension K and is known as the "kerf." Fig. 12 shows the relative cutting position of the teeth as they advance through the work. The cutting point C on the left will be followed by another to the right. This latter point, due to the wood being pushed forward will be relatively somewhat in advance of the first, etc. Let us now consider a blade containing, say, 100 teeth in its periphery. This means that 50 teeth will be set over to the left and 50 to the right. If we should deliberately set one tooth on each side a trifle further out than the rest, it will be evident that at every revolution these two teeth will rake their respective sides of the kerf a trifle deeper than the rest. If we should happen to be using a 3600-r.p.m. blade, and should be feeding the work at a rate of 75 ft. per min., the work would advance $^1/_4$ in. forward at every revolution of the blade, and these faulty teeth would mark or "score" the cut surface at every quarter inch. Fig. 14 shows a typical impression of a cross-cut surface, from which it may be distinctly seen how these teeth score the sides of the cut.

This marking or scoring is actually what takes place in every cut made with a saw containing set teeth. Although filing and setting machines are extensively used, even with these it is impossible to get all teeth absolutely uniform. It is, however, possible to reduce these score marks so that they will be very shallow and may be neglected. In this case they show up merely as scratches and are not relatively deep gouges which tend to spoil any surface. Ordinarily the conditions are such that but few cuts are made which have a uniform or slightly marred surface. To prove this, the author made several hundred cuts on all grades of wood with a new saw just off the filing machine and which any operator would have pronounced in excellent condition. Scored surfaces resulted in all cuts. This same saw blade was then revolved at high speeds and an ordinary whetstone held up against the teeth at the side, jointing them all off in the same plane. Cuts made with the blade after this treatment revealed smooth surfaces with slight scratches similar to that made by a hollow-ground blade containing teeth with no set.

This scoring condition is further aggravated by the ordinary vibration and rim-waving in a saw blade, and is particularly noticeable during the operation of ripping where either through undue heating and wabbling at the rim, or through human inability to hold the advancing wood squarely against the ripping gage, the rear teeth of the blade are allowed to rake the sides of the kerf as they come up through the table top. This is plainly indicated in Fig. 17. The rear teeth, of course, score the work in the opposite direction from those of the original cut, leaving a rough checkerboard surface. If the saw rim itself is not in vibration or wabbling, a steel splitter to keep the two sawn surfaces apart and away from the rear teeth will generally overcome this difficulty. However, even this expedient is not always successful.

In the true sense of the word, then, a smooth cut is produced only by saws having teeth with no set. A saw having its cutting points flush with the body of the blade and in the same plane, in addition to doing away with the scoring marks, polishes the cut surface with the body of the blade. While this action produces a beautiful finish, it sometimes causes undue heating and buckling at the rim, which is deterimental to the blade itself, and one of the causes for vibration and cracking. However, after the examination of hundreds of cut surfaces it was evident that to produce a smooth cut the first essential is to use a blade whose teeth contain no set, or whose teeth are set absolutely in the same plane. The exception to this, of course, is where the work is fed so slowly that the exaggerated teeth will wipe out their own marks, but this condition is prohibitive when production is considered.

CROSS-CUTTING

Cross-cutting is probably the most common and yet the most unsatisfactory sawing operation of all. This has evidently been due to the fact that in the past neither was the high-speed blade available nor did the layman or his employer understand the underlying principles of such apparently simple cuts.

When a piece of timber is pushed into a saw across grain, the action of the teeth against the wood fibers may well be compared to a person moving across a hay field and cutting a swath as he goes. He cuts at right angles to the stalk of the grass (the grain of the wood), and if he increases the speed of his sweep sufficiently, he can dispense with his scythe altogether and mow with an ordinary stick. This self-same principle applies to cross-cutting in wood. If the speed of the blade is sufficiently high, and the impact great enough to carry it through, the type of tooth is negligible, and one may cut as smoothly with a rip-saw tooth as with a cross-cut blade.

This was very forcibly brought out by the author's experiments with high- and low-speed cutting. It was proved that the smoothness of cut depends greatly upon the speed and force of impact with which the teeth come into contact with the cross-fibers of the wood, or, in other words, upon the force with which these cross-grains are "hit." Another factor governing the cut is the number of teeth coming into actual cutting contact with the surface. This practically means that we may employ any type of saw embodying

any type of tooth, but just so long as the peripheral speed of the blade is sufficiently high and the material is not fed too fast, a smooth cut can be expected. In order that this may be clearly understood, it will be necessary to explain exactly what takes place during the operation of cross-cutting.

Referring to Fig. 5, the teeth of cross-cutting blades are so designed that they act as knife points to sweep and sever the long fibers of wood across grain. Therefore these teeth must be sharp, pointed, and generally carry a bevel of from 25 to 45 deg. on their front edges, and one of from 35 to 45 deg. on their back edges. The first point to the left rakes the side of the wood on its sweep through its cutting arc, severing the fibers and leaving them hanging loose to the other side of the kerf. The next tooth following, being set to the right, severs the other ends of the fibers, which, being now completely cut off, are carried out and scavenged from the rapidly revolving blade.

Studies of freshly cut cross-grain surfaces reveal conditions which sharply distinguish the cutting of high-speed and low-speed blades. When a low-speed saw is used, if the cross-grains in the wood are too soft and pliable to respond to clean cutting, they are either torn off, crushed off, or literally "torn out by the roots," breaking in their weakest places. This results in a very rough surface. Referring to Fig. 6 which represents a greatly magnified section of a piece of softwood, the areas W are solid wood fibers and generally cut to hard surfaces. The circular portions S, which represent the pithy and cellular streaks, will tear off and crush when struck with a slow-speed blade. These particular fibers are very soft, even in hardwoods, and when a slow-speed blade strikes them they have a tendency either to bend over and crush off or to tear out under the plane of cutting. This will produce a rough surface covered either with projecting short fibers or pit marks. At other times, the bending over and crushing off of a fiber is also accompanied by a further rupture or cracking under the plane of cutting, with the result that when a freshly cut surface is rubbed slightly these ruptured particles will flake off from the main wood. This is shown by a sketch of a section at right angles to the plane of cut—Fig. 6. The crushed fiber at D is broken at its inner end and will flake off easily. Point F shows a fiber having torn out under the plane of cut, and E shows a protruding fiber which has been crushed off instead of being cleanly cut.

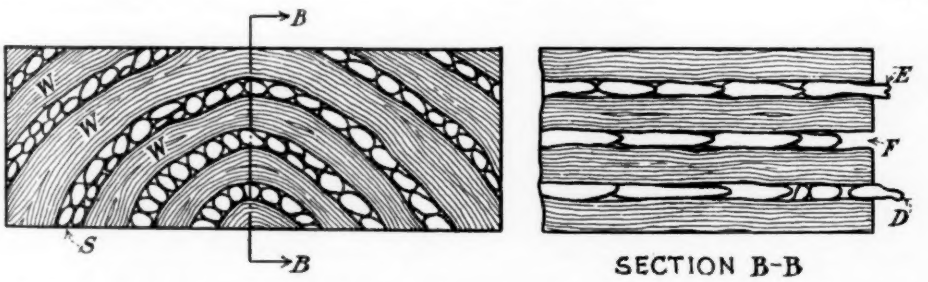


Fig. 6 Illustrating a Greatly Magnified Section of Wood Cut Across Grain. Areas *W* Are Solid Compact Fibers. Circular Streaks *S* Are Pithy Soft Fibers Which Tear Off as Shown on Section *B-B*
(Cross-section on line *B-B* looking in direction of the arrows.)

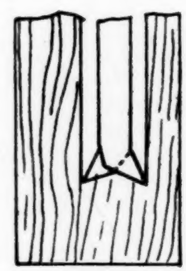


Fig. 7 Indicating Uncertain Paths Taken by Grain in Any Wood

The above effects are very noticeable in softwoods, but on account of the general texture and stiffness of hardwood fibers, the cuts are proportionately smoother than softwoods. Nevertheless these streaks of weak fibers or cells are evident even in hardwoods, and the roughness of hardwood cuts is attributed to this same cause. As a general rule, however, hardwoods give a great deal smoother surface.

Hardwoods are easily weakened and made pithy by overseasoning, overdrying, and undue exposure to alternate weather conditions. Where this is in evidence and the wood fibers are thus weakened, a slow-speed saw cut will reveal pit marks, which will either entirely disappear on a high-speed cut or be very little in evidence. As explained before, the high-speed blade "hits" these fibers sufficiently hard to sever them cleanly, while they are crushed or torn off by the slow-speed blade. A surface cut by a slow-speed blade is shown in Fig. 14. The broken lines represent pit marks where the grains have been crushed and picked out rather than severed cleanly. A similar cut, but with a high-speed blade, is shown in Fig. 15. It will be noted that except at the extreme left-hand side of this impression there are no pit marks and that the cut is smooth. This now brings us to another factor controlling the surface.

Even though a high-speed blade be used to cross-cut, the material must not be fed so fast that all the fibers are not swept by at least one tooth. If the feed is too fast, some of the fibers will be passed over only to be crushed off later instead of being clean-cut, and the resulting surface will appear similar to that of a slow-speed blade. Therefore, for any given feed in feet per minute, the more teeth contained in the blade the smoother will be the resulting cut. Referring to Fig. 15, the feed was started with a cross-feed of approximately 110 ft. per min. and was finished at approximately 7 ft. per min. The pit marks begin to disappear at about 75 ft. per min. and are entirely gone at 50 ft. This cut was made with a 3600-r.p.m. blade containing 100 teeth.

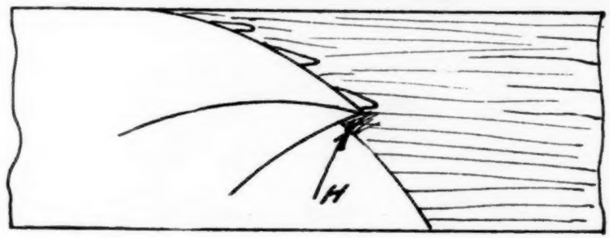


Fig. 8 Showing Action of Tooth During Operation of Ripping. For Explanation. See Text

It might seem, then, that some definite law might be arrived at which would state a relationship between cutting feeds, saw speeds, etc., for each and every different wood. However, on account of the different textures of fibers in the same grade of wood, even when cut from the same tree, it is found to be practically impossible to establish a definite law and expect it to hold true in all cases. One established, say, for kiln-dried cherry, might hold for one particular cherry plank, but would fail for the next.

However, since it was proved that the quality of a cross-cut surface is dependent upon the feed or the number of teeth coming into actual cutting contact with the surface, and upon the speed with which the fibers are "hit," the following general law or axiom may be relied upon as holding true for both hardwoods and softwoods:

> *The smoothness or quality of surface obtained by cross-cutting on any grade of hardwood or softwood is dependent upon the speed of the saw blade and the rate of cross-feed, and is independent of the type of blade or tooth.*

As explained before, the best surfaces cannot be obtained when using a saw with set teeth, and one must not be misled by the above axiom into believing that any type of blade is desirable just so long as its speed is sufficiently high. While the actual surface produced may be kept up to passable quality by keeping within certain feed limits for any particular saw speed, the production of the machine itself may be greatly enhanced or curtailed by the use of this or that blade, and the choice of the proper blade is an important factor.

This is best illustrated by referring to Fig. 14. Here the circular

marks made by the saw teeth are very noticeable. These scoring marks have been explained as being caused by some particular tooth projecting further out than the rest and raking the wood at every revolution. Now then, with a blade traveling at 3600 r.p.m., a single projecting tooth will rake the work at every inch with a feed of 300 ft. per min. If the feed is dropped to 75 ft. per min. these marks will evidence themselves every $^1/_4$ in. Assuming that that portion of the surface which shows scoring every $^1/_4$ in. is of sufficient quality to meet certain requirements, we can operate continuously at 75 ft. per min. and keep within limits provided that the blade is kept up to a speed of 3600 r.p.m. However, if we use a machine having a saw speed of only 2400 r.p.m., we shall of necessity have to drop the rate of feed to keep the rake marks within the $^1/_4$ in. limit and shall have to operate at 50 ft. per min. instead of at 75 ft. From this, then, is seen that with any blade on any machine, *the greater the r.p.m. of the blade, the greater the resulting production.*

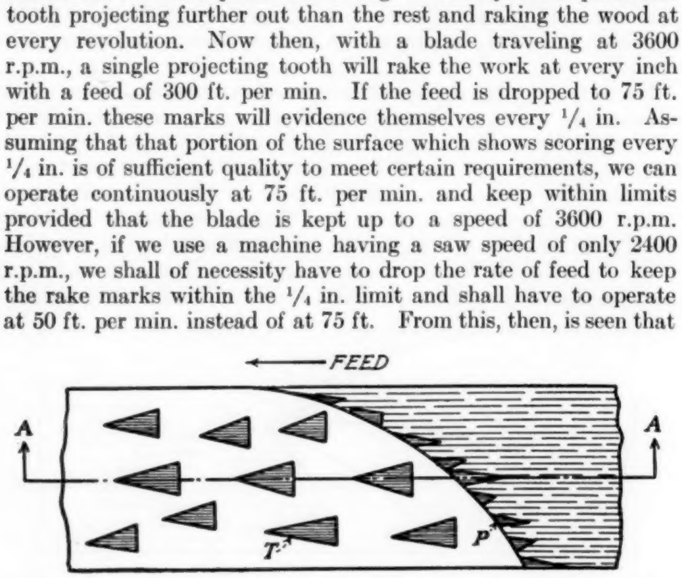


Fig. 9 Section Through a Rip-Saw Kerf Showing Path Ripped Out by the Teeth, also, the Flecked or Torn Surface (Magnified) as Indicated by the Pockets T and P. See Text

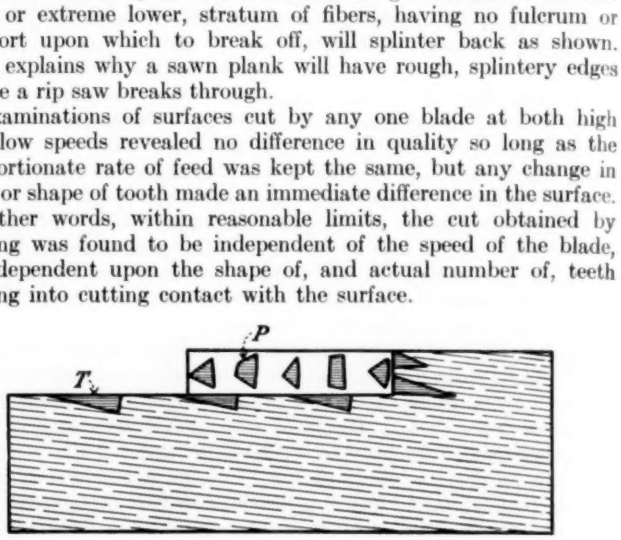


Fig. 10 Section on Line A-A of Fig. 9, Looking in Direction of Arrows

(Grain of wood in both Fig. 9 and this view is indicated by the light parallel lines.)

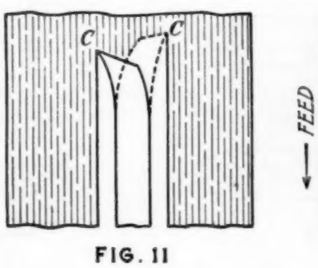


FIG. 11

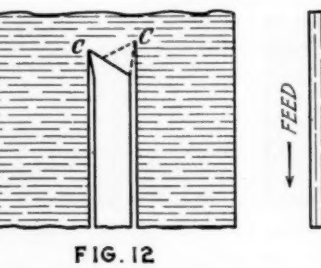


FIG. 12

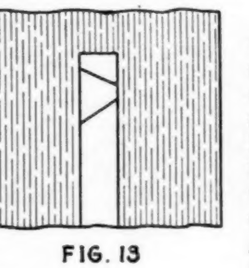


FIG. 13

Fig. 11 Position of Rip-Saw Teeth During Their Cutting Operation

Fig. 12 Position of Cut-Off-Saw Teeth During Their Operation

Fig. 13 The Combination Blade Cuts a Smooth Kerf, There Being No Set to the Teeth

From the above, then, at the same r.p.m., a blade having a greater number of teeth will naturally make a greater number of individual cuts per revolution, have actual cutting contact with a greater number of fibers, and will of necessity produce a better quality surface. Even though a passable and acceptable surface might be had with a rip saw as well as with a cross-cut saw, an operator would greatly curtail his production by using a coarse-tooth rip saw and proportionately lowering his feed rate to obtain the same quality of surface.

Ripping

One of the outstanding features shown in the experiments on ripping was the fact that owing to the uncertainty of the grain in any wood running in a straight line, there is no such thing as 100 per cent ripping. This is roughly illustrated by Fig. 7, the actual path of the grain being indicated by the lighter lines. The saw is seen to be traveling at a very long angle across grain, severing these cross-grain fibers wherever they happen to run into the kerf. Even though it be possible to start a saw kerf exactly parallel with the longitudinal fibers, these fibers will diverge one way or the other further along the kerf. At the points where these fibers leave or enter the kerf, an unsatisfactory cut is liable to be obtained.

A rip saw is in reality but a series of miniature adzes or chisels on a rapidly revolving circle, and the action of a saw in ripping is to chop or joint off the projecting ends of longitudinal fibers, the action being similar to that of the knives of a planer or jointer. Thus, when a piece of wood is pushed lengthwise into a rip saw, the long, raking teeth bite into the end grains and take out a piece, the size of which depends upon the rate with which the work is being pushed forward. After the tooth has taken its hold upon the wood—Fig. 8—the fibers thus entrapped will either cut off directly or crush off, using the underlying fibers as a fulcrum or chip breaker at some such point as H. This latter is not conducive to a clean cut, and a section through the circular portion of a kerf will look similar to those shown in Figs. 9 and 10. The indentations or ragged holes P are caused by the fibers breaking loose back under the surface, the lower fibers acting as a fulcrum. The last, or extreme lower, stratum of fibers, having no fulcrum or support upon which to break off, will splinter back as shown. This explains why a sawn plank will have rough, splintery edges where a rip saw breaks through.

Examinations of surfaces cut by any one blade at both high and low speeds revealed no difference in quality so long as the proportionate rate of feed was kept the same, but any change in type or shape of tooth made an immediate difference in the surface. In other words, within reasonable limits, the cut obtained by ripping was found to be independent of the speed of the blade, but dependent upon the shape of, and actual number of, teeth coming into cutting contact with the surface.

To illustrate, if we try to rip with a blade having cross-cut teeth shaped similar to those in Figs. 5 and 7, the tooth to the left will force its way into the long fibers, and cut out a path its exact shape. The next tooth following to the right will perform a similar operation. It has been explained that this self-same action in cross-cutting would suffice to completely sever the cross-grains and cause them to scavenge, but since in ripping the wood fibers are running parallel with the blade, the V-section remaining between the two opposite teeth will be heavily supported at one end and will either have to be taken off by the body of the tooth through main force of impact, or will be crushed back and broken off by the power pushing the work forward. This results in a tremendous increase in power required and undue heating of the blade. However, the instant the front surfaces of these teeth are straightened up square to the blade and their actual cutting edges are made to lead off at the correct angles from the point, making the tooth into a miniature chisel, an immediate difference is noticed both in power consumption and quality of cut surface obtained.

It is not necessary to go into detail as to the exact shape of rip-saw tooth necessary to obtain a good cut with economical power consumption, but there are two or three characteristics which they must all have. They should be backed up on top to provide for great strength, should have undercut front edges, should have their front edges filed nearly square with the blade body, and should have their cutting edge leading off nearly at right angles to the blade body, measuring from the point of set. With this type of tooth the sharp cutting edges will "chop off" the protruding longitudinal fibers as the work advances, and the undercut front edges will provide for sufficient scavenging space to permit of very rapid ripping.

Due to the necessarily great distance between rip-saw teeth, fewer teeth come into actual cutting contact with the surface than with any other type blade. On this account, and on account of the impossibility of obtaining a 100 per cent ripping operation, the cross-grain fibers which intersect the kerf at long angles are

not likely to be struck with a tooth. Consequently these fibers will tear out or crush off, and triangular pits T will appear as indicated in Fig. 9. These pockets or pits run back under the surface far enough, following the grain of the wood, to cause the succeeding layer of fiber to act as a fulcrum and result in their rupture.

However, since these intersecting fibers are relatively far apart, if a fine-tooth rip saw be employed or the work be fed reasonably slow, the resulting surface is uniform and smooth at all nominal saw speeds. From the above, then, there may be derived the single law or axiom which will apply to the operation of ripping, both in hardwoods and softwoods:

The smoothness or quality of surface obtained by the operation of ripping in any grade of softwood or hardwood is dependent upon the type of tooth embodied in the blade and the rate of feed, and is independent of the speed of the saw.

Mitering

The operation of "mitering" consists of cutting through wood at a well-defined angle to the fibers. In other words it is a combined ripping and cross-cutting action. Since, in most woodworking operations it is common practice not to finish a miter after cutting, it is paramount that a saw for performing this work must have two outstanding essential qualifications: It must be able to perform ripping and cross-cutting at one movement, and it must make a smooth and finished cut at one passage of the blade.

Since it is impossible to obtain a smooth finish with any blade in which the teeth are set, it obviously follows that a miter saw must consist of cross-cut and ripping teeth without set.

Examinations of hundreds of cut surfaces in both hardwoods and softwoods revealed that all the influences which govern the actions of both ripping and cross-cutting combine to govern the finish of a miter cut. Thus, a miter cut is dependent on the speed of the blade, the rate of feed, and the type of tooth. The latter does not seem to have as great an influence as the first two, because the cross-cutting action holds sway until the angle of cut approaches closer to that of straight ripping. However, as straight ripping is approached, the shape of the tooth plays an increasingly greater part. From the above, then, the following law or axiom may be stated for mitering in both softwoods and hardwoods:

The smoothness or quality of surface obtained by mitering in any grade of softwood or hardwood is dependent upon the speed of the blade, the type of tooth employed, and the rate of feed.

General Discussion

The main difference found between working on hardwoods and softwoods lies in the fact that the hardwood grains, being stiffer, always produce a smoother cut under the same conditions. The foregoing laws pertaining to cross-cutting, ripping and mitering hold true for both grades of wood, but it can be expected that for a given quality of cut, the stiffer the grain or wood fiber, the better the production of the machine, or, with a given machine production, the stiffer the wood fiber, the better the quality of cut.

It is absolutely essential in good woodworking practice to obtain as smooth a cut as possible from the economical standpoint of both waste in expensive fine woods and actual labor cost in finishing off the cut surfaces. With this in mind the author submits the following points to be observed by the woodworker, these points being the results of experience and proved by the experiments discussed:

1 For any cutting operation, the finest surfaces can never be obtained with saws containing set teeth.
2 For any cutting operation, the rate of feed, or the number of teeth coming into actual cutting contact with the surface, has the greatest common influence over quality of cut.
3 In cross-cutting it is essential that the speed of the blade be kept high.
4 In ripping it is essential that the shape of the tooth be correct, and that a splitter be used.

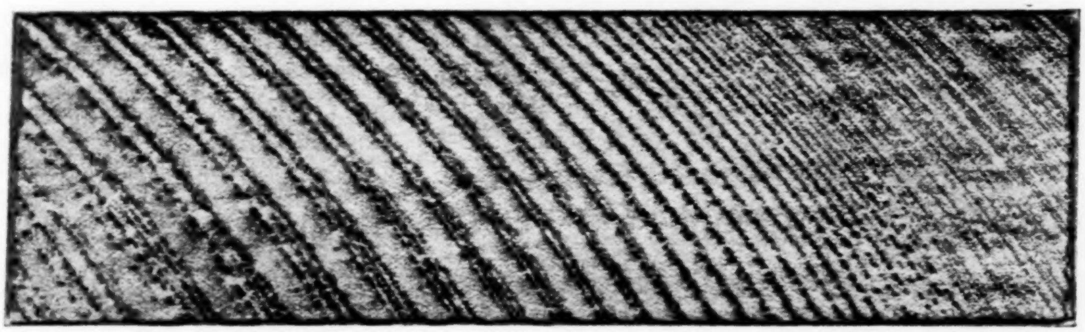


Fig. 14 Slow-Speed-Saw Cross-Cut on Cherry Plank. Feeding Rate from Left to Right, 100 Ft. Per Min. to 3 Ft. Per Min.

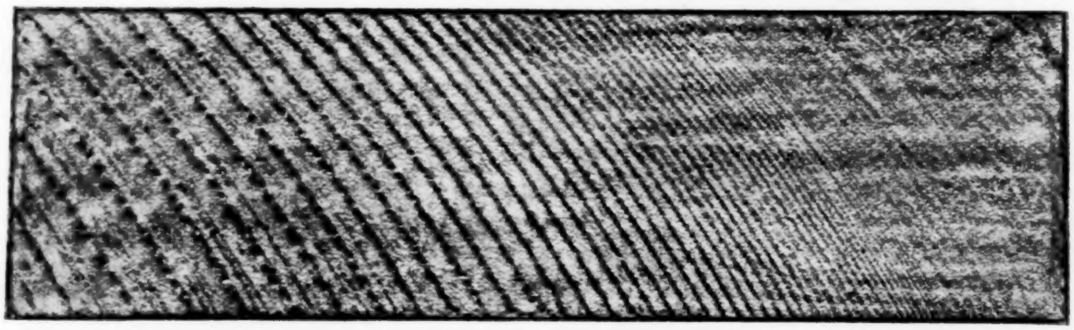


Fig. 15 High-Speed-Saw Cross-Cut on Cherry Plank. Feeding Rate from Left to Right, 110 Ft. Per Min. to 7 Ft. Per Min.

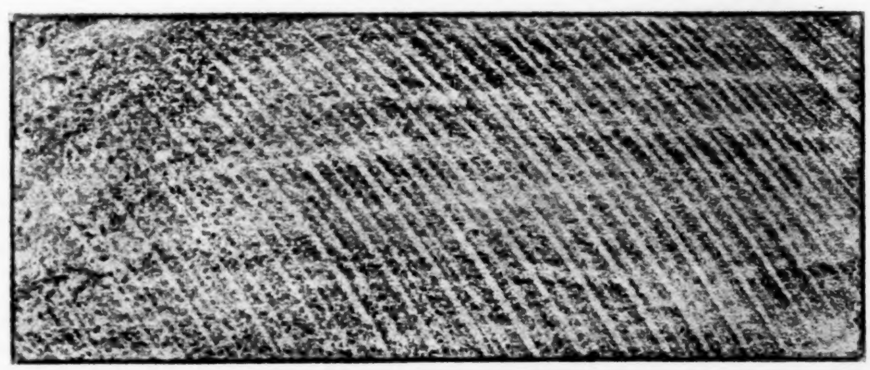


Fig. 16 High-Speed Saw (Miter Saw) Cross-Cut on Cherry Plank. Uniform Rate of Feed at About 75 Ft. Per Min.
(Teeth in this type saw without set and marks on surface merely scratches.)

5 Better results will be obtained in any sawing operation if sufficient power is supplied to keep the blade up to speed under all conditions. In other words, provide an excess of power over ordinary conditions.

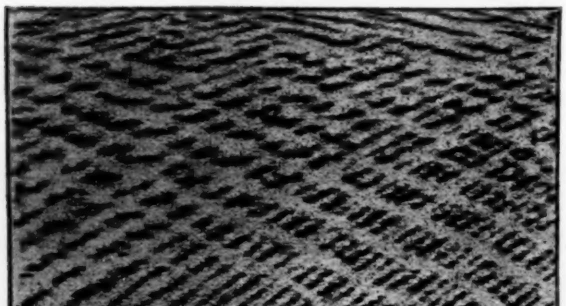


Fig. 17 Showing Effect of Back Rake or Cutting at Rear of Saw. Makes Rough Checkerboard Surface

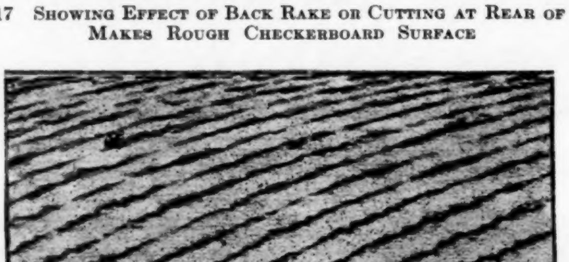


Fig. 18 Showing Same Surface of the Board as in Fig. 17 but with no Back Rake on Rear of Saw. Wood Grooved in One Direction Only, the Rear Teeth of Blade not Touching After the Initial Cutting

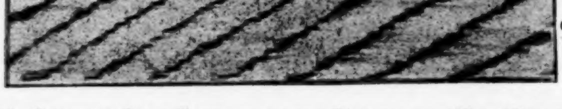


Fig. 19 Typical Surface as Ripped by a Miter Saw

(The circular marks shown are merely scratches in the surface and are not deep like those imparted by the regular rip-saw blade with set teeth.)

It must not be assumed from the above that all saw blades having set teeth should be discarded for others. It is true that hollow-ground blades and the so-called planer blades will produce a uniform and beautiful cut, but these surfaces are generally produced at the expense of power and production. A woodshop owner might well afford to sacrifice power and rip his oak or high-grade boards on a straight-line edger, using a hollow-ground blade and feeding his work with an automatic medium-slow feed, if this procedure would save him the after expense of finishing off with a jointer. On the other hand, with the handling of ordinary building material and form lumber, where a great deal of hand-feed ripping is done, also, where economy of material and quality of ripped surface is not so essential, it would be foolhardy to use any but a saw having set teeth. A blade with set teeth is easier to handle in its operation, easier to keep in shape, consumes less power, and, where the work is to be finished off afterward on a jointer or is to be left rough, is the type to be used.

Within the last few years, however, the demand for hollow-ground blades has increased, due to the fact that on small surfaces it is found possible to rip perfect glue joints with a resulting saving of labor and material. In his experiments on ripping the author ripped a slab of hardwood which glued as perfectly as one made on a jointer; but the extra care and labor involved, also the upkeep and attention required on such a blade, does not always warrant its use, except in such shops as may be equipped with filing machines and automatics for performing just this sort of work and have skilled mechanics whose duty is to keep all blades in constant good shape.

A prominent saw manufacturer has made the statement that in his experience he has found that one of the main essentials of good sawing is the provision of sufficient power or "kick" in the blade to drive it through the work. This is very true, and with the development of the motorized saw spindle the woodworker will come to realize that it is actual economy to provide an excess of power upon which it will be possible for him to call whenever it is necessary to do so.

One of the greatest mistakes made by woodworkers is the use of inadequate driving power back of their blades. Experience has shown that it is folly to install a 3600-r.p.m. blade in a machine if the driving power back of it is not sufficient to keep up its full-load speed. A good many consumers are of the opinion that a 3-hp. motor is sufficient to handle their work and refuse to install a 5-hp. machine at practically no additional cost. This is a grave error for the following good reason: It makes no difference what class of work is placed on a machine, occasions will arise where the demand on power is severe, such as wet wood, sap streaks, hard spots, knots, etc. Now if the machine is equipped with a small motor with insufficient power to keep its blade up to speed under these short-time demands, the effect of the high-speed blade is lost and a slow-speed machine would suffice just as well. Again, there are but very few sawing operations which do not require more than 3 hp. during actual operation. There are exceptions to this, of course, but they are few. Since it requires practically no more idling power for a 5-hp. motor than for one of 2 or 3 hp., and since the actual power consumption while developing 4 hp. is less with a 5-hp. motor than with a 2- or 3-hp. motor, common sense points to the advisability of using a larger motor.

The author is of the opinion that woodworking manufacturers should specialize on the 5-hp. motor for all general cut-off work and variety work, equipping their respective machines in this manner, and placing still larger motors on their rip saws when occasion so demands. The consumer should be educated into seeing the advisability of such equipment both from the standpoint of economy and that of production. For general work in cabinet shops, furniture factories, sash and door plants, etc., a minimum of 5-hp. equipment should be used for sawing, and the machine so equipped will never be found wanting. The exception to this last statement will be found only in heavy ripping and dadoing, and small bench work.

It is known that under certain conditions of heat treatment certain special steels, notably nickel-chrome, become very fragile, although the other mechanical properties remain sensibly constant. A systematic study was made by L. Guillet of a steel with the following percentage analysis: Carbon, 0.26; nickel, 3.76; chromium, 0.67; manganese, 0.54; silicon, 0.11; sulphur, 0.037; and shock-test pieces were submitted to the following treatment: tempered in oil at 900 deg. cent. after heating for 20 minutes; reheated to 650 deg. cent., and cooled between 650 deg. cent. and 410 deg. cent. in 35 hours; and then cooled in air from 410 deg. cent. to room temperature. Other test pieces were submitted to similar treatment, except that the two reheats were reversed in order after tempering. The author found that with the last treatment the metal became fragile. This fragility was lost at a temperature of 200 deg. cent. Similar tests show that the metal heated to 500 to 550 deg. cent. and cooled in air is not fragile, but becomes fragile only if the cooling is slow. Microscopic examinations show no difference between the two treatments, nor does the expansion furnish any explanation. (*Machinery*, August 12, 1926, p. 563.)

Boiler and Stoker Performance at Hell Gate Power Station

By H. W. Leitch,[1] New York, N. Y.

The object of this paper is to show the trend of development of stoker and boiler installations in a modern power house whose extensions have been made at fairly regular intervals, and to give the effect of these yearly additions on the overall efficiency and maintenance. There is included a comparison of the essential features of the tests of the several types of installation, with a detailed test of the latest.

The Hell Gate Station of the United Electric Light and Power Company now has an installed main-turbine capacity of 285,000 kw., 50,000 kw. of which has been installed within the last five months, and an installed boiler horsepower of 35,000 of which 3770 boiler hp. has been installed within the same length of time. It has sent out from the bus over a billion kilowatt-hours in the last twelve months. This is at the average rate over the 12 months of 3.53 kw. per installed boiler horsepower, although the load factor was only 50 per cent.

Original Boilers

The original installation of twelve 1890-hp. boilers was placed in service between the middle of November, 1921, and the early part of 1922. These boilers, as shown in Fig. 1, are twenty tubes high with interdeck superheaters separated from the furnace by a bank of six tubes. The tubes are 3 in. in diameter, 20 ft. long and have a pitch of 15 deg. They are fired from each end by 14-retort stokers, 17 tuyeres long. The clinker pit and grinding rolls are located at the center of the furnace between the ash-discharge ends of the two stokers. These boilers are not provided with economizers, although they are equipped with induced-draft fans for operation at high ratings. These fans are adequate to accommodate economizers, should their installation later be indicated.

Boilers Nos. 51, 52, and 53

At the time of preparing the layout for the original twelve boilers the short stoker had reached a high state of development, while the long stoker was still in somewhat of an experimental stage. When, however, it became necessary to increase the boiler capacity, there had been further developments in stoker design, so that three boilers were installed with economizers and fired at one end only by 14-retort stokers, 33 tuyeres in length. These boilers are known as Nos. 51, 52, and 53, and a cross-section of them is shown in Fig. 2. The clinker pit, equipped with a two-roll crusher, is located in the pocket formed at the rear wall of the boiler and the ash-discharge end of the stoker. The superheater is located on top of the first pass. The side walls of the furnace are water-cooled by means of fin-type tubes connected into the boiler circulation, an innovation at that time. The portion of these water tubes along the fire line of the stoker is covered by protective tiling.

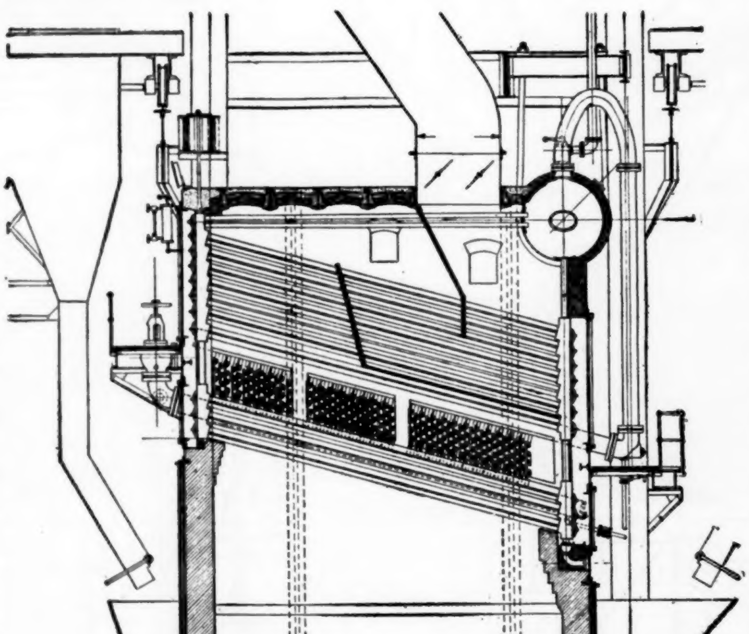


Fig. 1 Cross-Section of Original Boiler Setting, Hell Gate

When these boilers were first placed in operation some difficulty was experienced with the breakage of stoker rams and with burning of certain parts of the stoker. These difficulties, however, were soon overcome by the manufacturer, and the reliability of this type is now equal to that of the older types. These boilers are operated at high rates of driving, but the water-cooled side walls have reduced the furnace-brickwork maintenance to a minimum. The superheaters had been purchased before it was decided to install water walls, and owing to the fact that data were not available it was decided to install the superheaters as purchased, although it was realized that the desired temperature would not be obtained.

Boilers Nos. 61, 62, and 63

One year later, late in 1924, three more units were placed in operation and are known as Nos. 61, 62, and 63—see Fig. 3. These are similar in many respects to those of the second installation, which have proved so efficient and flexible, except that instead of being 16 tubes high these are 12 high, with the superheater, as before, located at the top of the first pass. This effectively provides the superheat and increases the overall boiler and economizer efficiency, except at very high rates of driving. The superheat is slightly higher than was expected, but at no rate of driving does it exceed temperatures considered safe. The stoker wind box is divided into four compartments so that the air pressure to any one of the four sections may be controlled independently. This feature has been found valuable, particularly at high rates of driving. The economizers in this installation incorporate some new features in design. The tubes and cast-steel headers are coated inside and out with a lead alloy by a process very similar to tinning. The tubes are held in the headers by taper fits similar to the method employed with cast-iron economizers.

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Contributed by the Power Division and presented at the Providence, R. I., Meeting, May 3 to 6, 1926, of The American Society of Mechanical Engineers.

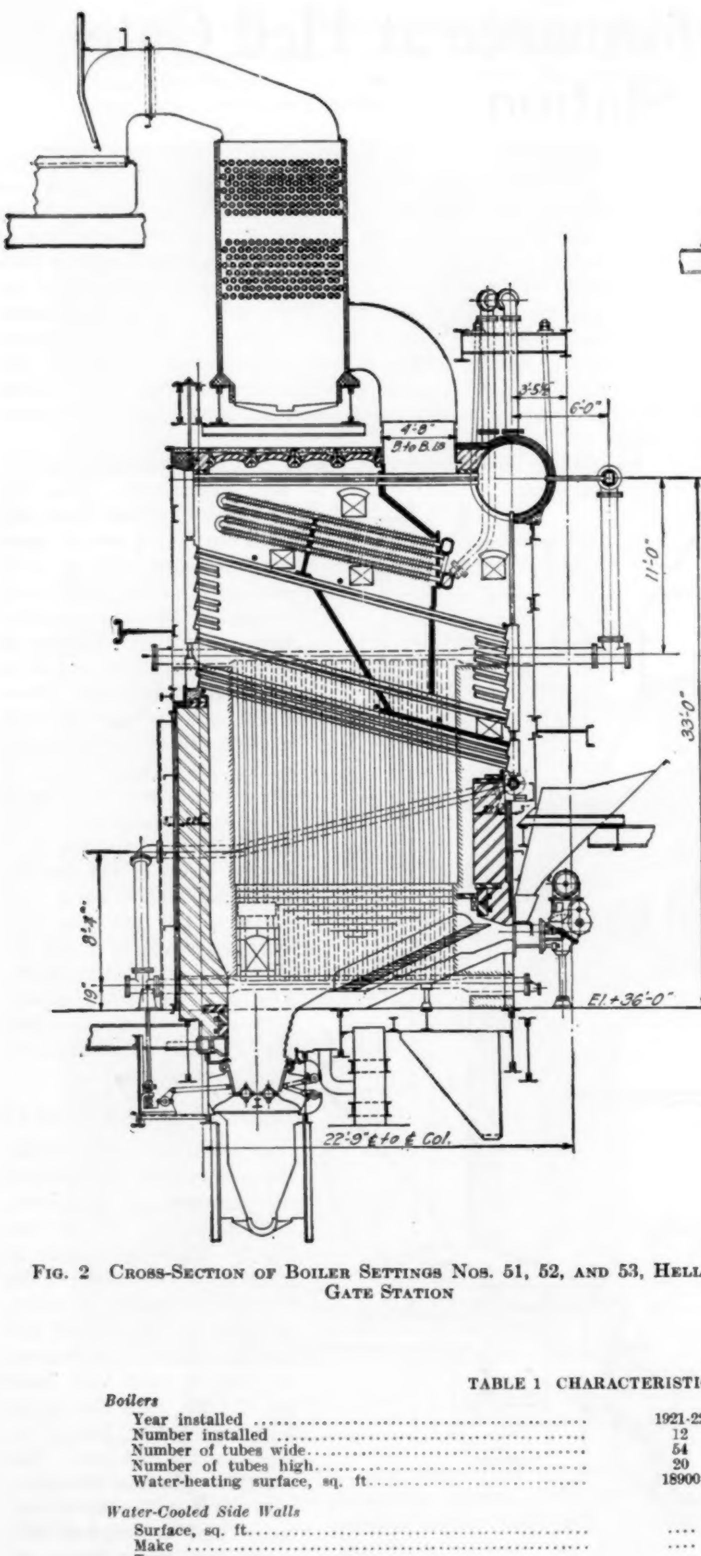

FIG. 2 CROSS-SECTION OF BOILER SETTINGS NOS. 51, 52, AND 53, HELL GATE STATION

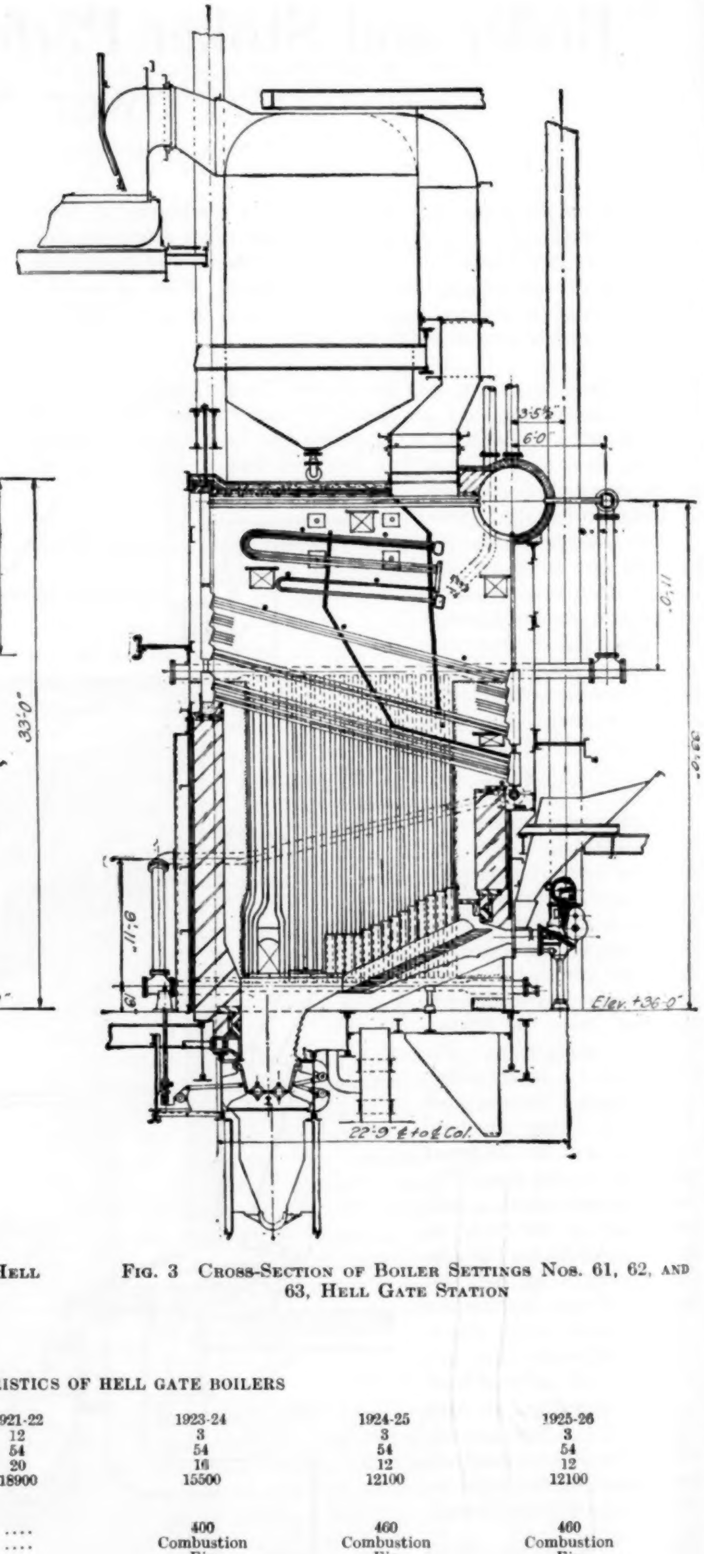

FIG. 3 CROSS-SECTION OF BOILER SETTINGS NOS. 61, 62, AND 63, HELL GATE STATION

TABLE 1 CHARACTERISTICS OF HELL GATE BOILERS

Boilers				
Year installed	1921-22	1923-24	1924-25	1925-26
Number installed	12	3	3	3
Number of tubes wide	54	54	54	54
Number of tubes high	20	16	12	12
Water-heating surface, sq. ft	18900	15500	12100	12100
Water-Cooled Side Walls				
Surface, sq. ft	....	400	460	460
Make	....	Combustion	Combustion	Combustion
Type	....	Fin	Fin	Fin
Superheater				
Surface, sq. ft	2135	7410	10450	4000
Make	Superheater Co.	Power Specialty	Power Specialty	Superheater Co.
Type	Elesco	Foster	Foster	Elesco
Location	Interdeck	Top first pass	Top first pass	Top first pass
Economizers				
Surface, sq. ft	....	13824	12100	10692
Make	....	Power Specialty	B. F. Sturtevant	Power Specialty
Type	....	Foster	Lead-alloy coated	Foster
Stokers				
Number per boiler	2	1	1	1
Number of retorts per stoker	14	14	14	14
Number of tuyeres	17	33	33	33
Projected grate area, sq. ft	472	378	378	378
Make	American Engrg.	American Engrg.	American Engrg.	American Engrg.
Type	Taylor AA7	Taylor HC7	Taylor HC7	Taylor HC7
Furnace volume, cu. ft	8000	6500	6500	6500

TABLE 2 CHARACTERISTIC RATIOS OF HELL GATE BOILERS

Year installed	1921–22	1923–24	1924–25	1925–26
Ratio of total water heating surface to grate area	40	42.1	33.3	33.3
Ratio of furnace volume to total water heating surface	0.423	0.41	0.517	0.517
Ratio of furnace volume to projected grate area	16.9	17.2	17.2	17.2
Ratio of superheating surface to total water heating surface	0.113	0.466	0.832	0.317
Ratio of economizer surface to total water heating surface	....	0.87	0.965	0.85

BOILERS NOS. 71, 72, AND 73

In the latter part of 1925 a further addition of three boilers

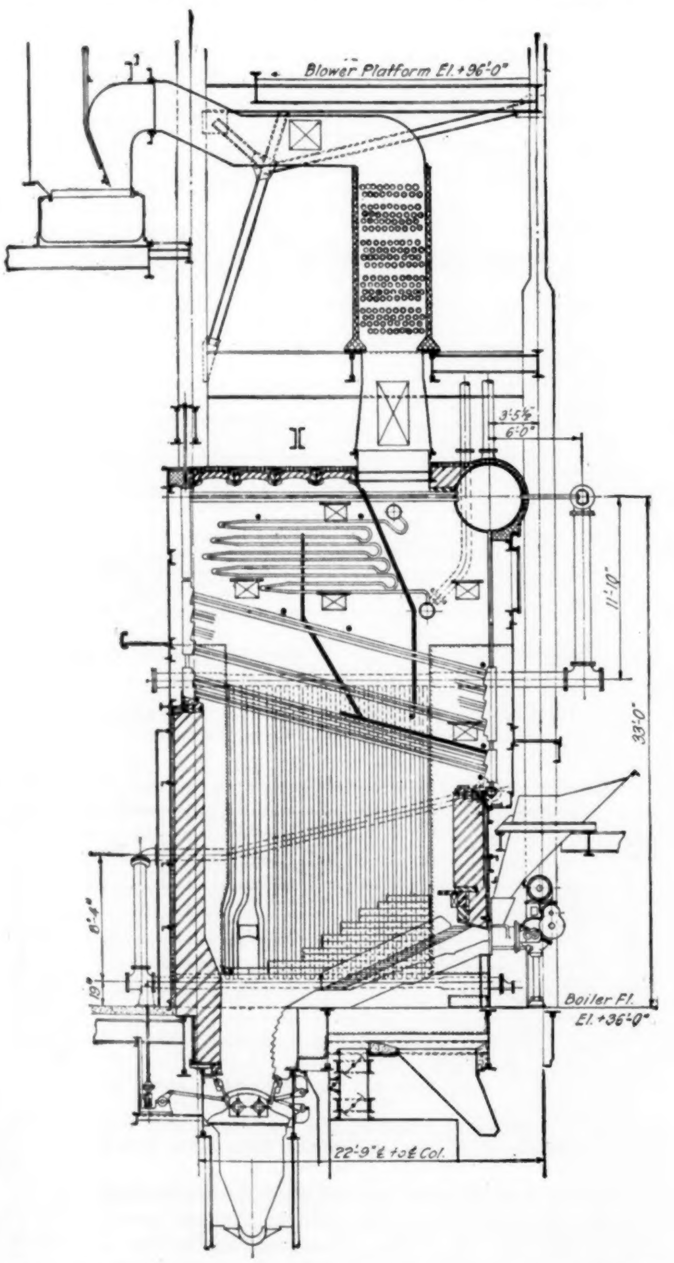

FIG. 4 CROSS-SECTION OF BOILER SETTINGS NOS. 71, 72, AND 73, HELL GATE STATION

was made, Nos. 71, 72, and 73—see Fig. 4. It was realized that if the stoker could be lengthened the efficiency curve would have less drop at high rates of driving, and studies were made to incorporate a stoker 37 tuyeres long. The design, however, indicated such weaknesses due to the limitations imposed by the boiler-house structure, which was erected as a unit, that the proposition was abandoned and stokers of the same length as those previously installed—33 tuyeres—were purchased. The stoker which was tested has certain refinements, notably the ability to adjust the travel of the lower rams. It is thought that this will be of particular value with coals of poorer grades than are now being used at the station.

The characteristics and ratios of these four types of boiler installation are given in Tables 1 and 2.

Referring to the cross-section of the most recent installation, Fig. 4, the greater simplicity of the layout is apparent. The economizers on the end boilers of the row are installed directly above the boiler uptake, eliminating the usual cinder pan and one elbow, and covering the entire width of the boilers. The tubes

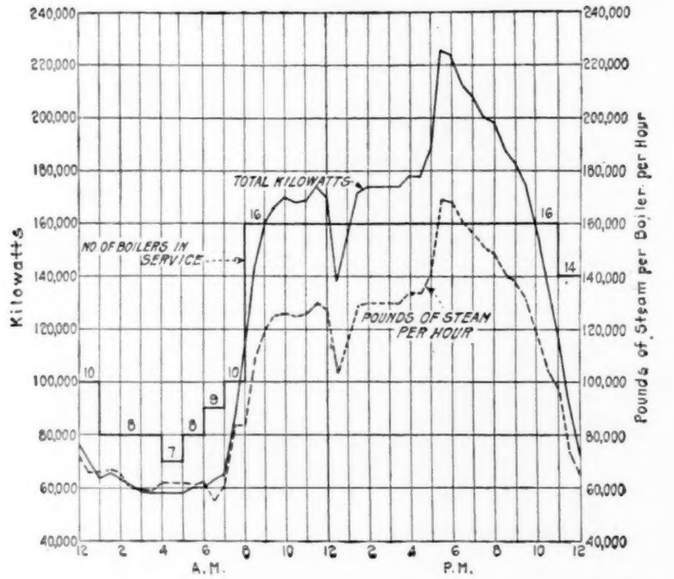

FIG. 5 TYPICAL DAILY LOAD CURVE, HELL GATE STATION—STATION OUTPUT, 3,141,000 KW-HR.

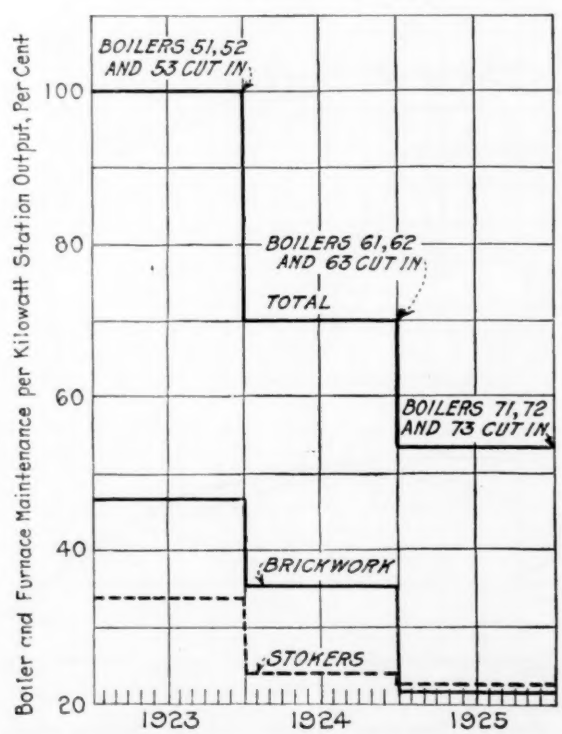

FIG. 6 BOILER-FURNACE MAINTENANCE COSTS, HELL GATE STATION

are 22 ft. long, an increase of 6 ft. over any previously installed in the station, permitting a much more economical distribution of surface, with a consequent reduction in the number of headers required. The greater width as compared to the previous installations is favorable to the improvement of distribution of gas flow through the unit, and there is no tendency for the economizer to cause an uneven distribution of gas flow through the boiler. The economizer on the inside boiler of the row is offset sufficiently so

that the tubes may be withdrawn from any economizer without interference. Washing the economizer has been superseded by soot blowing.

Influence of Later Boilers on Maintenance and Efficiency

In order to show the character of the service from this station

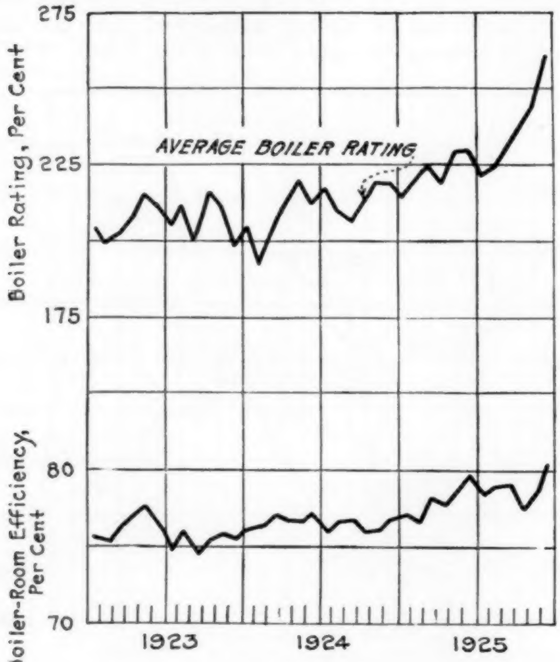

Fig. 7 Increase in Boiler-Room Efficiency with Introduction of Improved Boiler Units, Hell Gate Station

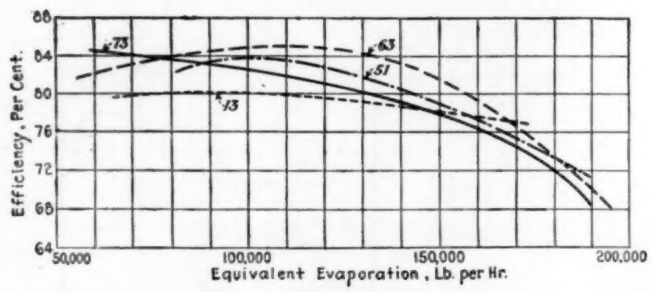

Fig. 8 Efficiency Curves, Boilers and Superheaters, Hell Gate Station

(Equivalent evaporation of boiler and superheater.)

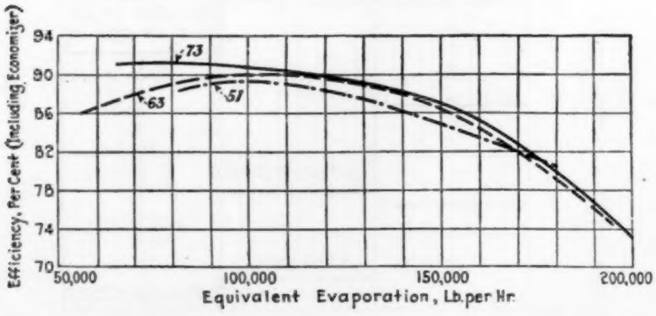

Fig. 9 Overall Efficiency Curves, Boilers, Superheaters, and Economizers, Hell Gate Station

(Equivalent evaporation of boiler and superheater.)

there is shown in Fig. 5 a typical autumn daily load curve with the number of boilers steaming and the steam generated per boiler in pounds per hour.

It has been demonstrated that the improvement in design of each row of boilers has contributed materially to the operating results of the station. Fig. 6 shows the decrease in boiler and furnace maintenance over the past three years with the dates of the successive additions indicated. The two major items of this maintenance—stokers and brickwork—are given in the lower curves. The marked decrease in brickwork maintenance is apparent, due entirely to the installation of the water-cooled walls on all of the newer boilers.

In the lower curve of Fig. 7 the gradual increase of boiler-room efficiency is shown. This is in spite of the increase in average rate of driving as shown in the upper curve.

The boiler and superheater efficiency curves of the four types of installation are given in Fig. 8. The flatness of the curve for No. 13 boiler is very pronounced, but as an operating proposition it is impossible to maintain as high rates of driving on boilers of this type for sustained periods as on the more recent type due to clinker difficulties. Had it been possible to maintain the same grate area with the more recent additions, the performance curves

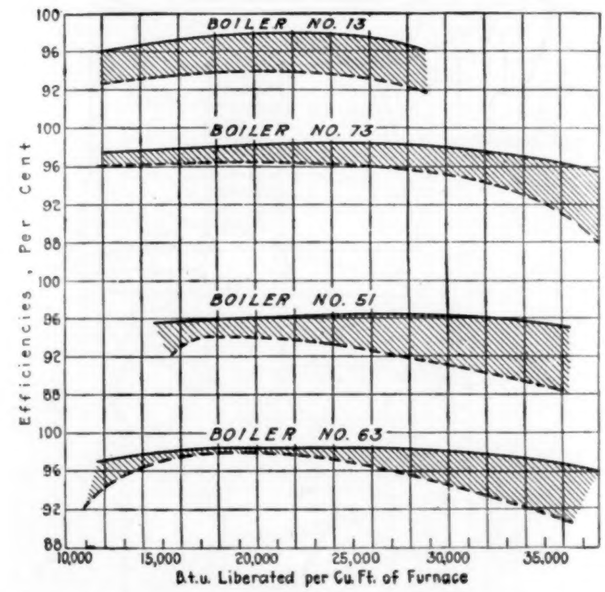

Fig. 10 Furnace Efficiencies Based on Saturated-Steam Temperatures, Hell Gate Station

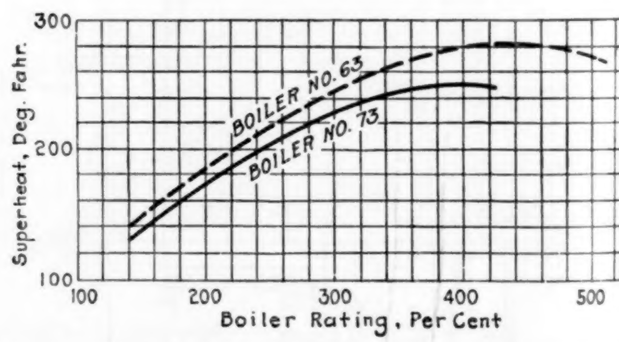

Fig. 11 Superheater Performance of Dissimilar Superheaters Installed on Similar Boilers, Hell Gate Station

would have been elevated somewhat at the higher rates. It was necessary, however, to sacrifice some of the grate area in order to increase the capacity of the ash-disposal mechanism as a means toward greater reliability and reduced maintenance.

The apparent superiority of boiler No. 63 over the other boilers is probably due to certain structural differences which were incorporated in the furnace of this boiler for experimental purposes. Air-admission tuyeres were provided just above the fire in the front wall and segregated in zones provided with manually controlled dampers. The side-wall tuyeres were also arranged somewhat differently, but it is not believed that this had any appreciable effect. While from the standpoint of tests the efficiency appears superior, it is doubtful whether any material gains could be effected in ordinary operation, due to the human element.

In the curves of overall efficiency, Fig. 9, however, the successive improvement in the last three installations is shown.

TABLE 3 TESTS OF BOILER NO. 73

General							
1	Test No.	1	2	3	4	5	6
2	Date of test, 1926	2/18–19	2/19–20	2/23–24	3/3–4	3/9–10	3/30–31
3	Duration, hr.	24	24	25	24	22	24
4	Rate of driving, per cent of builder's rating	153	223	275	275	343	427
5	Coal fired per hr., lb.	5512	8338	10430	10354	13777	18200
6	Dry coal fired per hr., lb.	5200	7960	9913	9820	12960	17202
7	Actual water per hr., lb.	59957	85716	105940	105040	131300	161580
8	Equiv. water per hr., boiler and superheater, lb.	66500	96700	119200	118800	148900	184040
9	Equiv. water per hr., boiler, superheater and economizer	72500	105500	132800	132000	153400	205207
10	Actual water per lb. coal fired, lb.	10.87	10.28	10.15	10.15	9.54	8.88
11	Quality of steam entering superheater, per cent	99.2	98.8	98.6	99.1	98.9	98.9
Temperatures, Deg. Fahr.							
12	Boiler room	77	68	63	60	68	76
13	Air for combustion	72	63	65	65	72	72
14	Feedwater entering economizer	149	150	140	140	141	142
15	Feedwater entering boiler	245	258	264	263	274	268
16	Flue gases leaving boiler	458	523	576	612	653	659
17	Flue gases entering economizer	437	494	569	557	602	...
18	Flue gases leaving economizer	186	198	268	230	254	300
19	Superheated steam — east outlet	559	611	624	641	671	664
20	Superheated steam — west outlet	560	590	630	628	651	661
21	Average superheat	145	185	212	220	245	247
Pressure, Lb. Per Sq. In. Gage							
22	Water at economizer — inlet	342	343	346	342	342	342
23	Water at economizer — outlet	340	338	337	333	323	314
24	Steam at superheater — inlet	277	282	281	280	284	291
25	Steam at superheater — outlet	277	279	278	276	279	281
Drafts, Inches of Water							
26	Air duct	+3.0	+3.1	+3.2	+3.3	+4.5	+5.1
27	Wind box	+ .25	+1.1	+2.1	+1.9	+3.3	+3.7
28	Extension grate	+ .1	.0	+ .3	+ .4	+ .6	+ .6
29	Over fire	— .02	— .00	— .02	— .02	— .01	— .03
30	Leaving boiler	— .04	— .23	— .44	— .44	— .72	—1.17
31	Leaving economizer	— .21	— .73	—1.33	—1.22	—2.08	—2.99
32	Induced-draft-fan inlet	— .21	— .83	—1.48	—1.45	—2.28	—3.41
33	Loss through boiler	.06	.23	.42	.42	.71	1.14
34	Loss through economizer	.17	.50	.89	.78	1.36	1.82
35	Loss through boiler and economizer	.23	.73	1.31	1.20	2.07	[illegible]
36	Induced-draft-fan speed, r.p.m.	0	123	199	[illegible]	[illegible]	[illegible]
37	Stoker-motor speed, r.p.m.	249	457	522	538	[illegible]	[illegible]

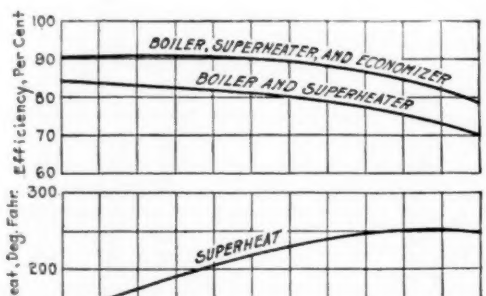

FIG. 12 TESTS OF BOILER NO. 73, HELL GATE STATION

In Fig. 10 are shown the furnace efficiencies of the four types of installation based on saturated-steam temperature. In each case the shaded area represents the radiation and unaccounted-for losses, so that the actual furnace efficiency lies somewhere in this band and is not subject to accurate measurement.

Fig. 11 is self-explanatory, but in considering the curves it should be borne in mind that the superheater of boiler No. 63 was of the extended-surface type and had a rated effective surface of 10,450 sq. ft., while that of boiler No. 73 is of the plain-tube type with a surface of 4000 sq. ft. Each superheater, however, occupies substantially the same volume.

TESTS OF BOILER NO. 73

The tests of boiler No. 73, reported in Figs. 12, 13, and 14, and Table 3, were conducted shortly after the boiler was placed in service and the usual care was exercised to secure high accuracy. The coal was weighed by weighing lorries, the accuracy of which had been checked by dead weights. The water evaporated was measured by means of a venturi meter and mercury manometer which had been standardized by the use of weighing tanks. The

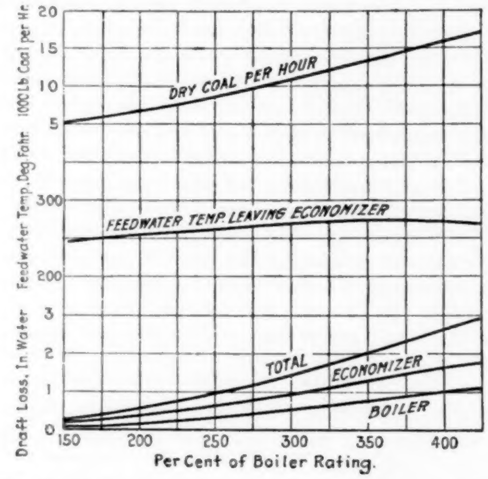

FIG. 13 TESTS OF BOILER NO. 73, HELL GATE STATION

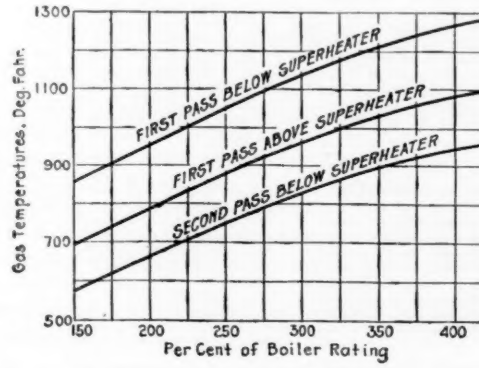

FIG. 14 TESTS OF BOILER NO. 73, HELL GATE STATION

steam flow from the boiler was also measured by a Bailey meter and used as a check against the measured water.

In conducting the tests the feedwater flow was maintained constant by regulating the feed valve in accordance with the indications of the manometer. The level of the water in the boiler was in turn controlled by regulating the combustion air supplied by the forced-draft fans in accordance with the height of the water in the gage glass. This was accomplished simply by maintaining the air-duct pressure slightly in excess of that required by the average rate of driving, and slight fluctuations were taken care of by means of the hand dampers at the stoker. Briefly, the flow of water to the boiler was fixed, while the amount of heat imparted to the boiler was regulated to maintain an average rate of evaporation corresponding with the rate at which the feedwater was admitted. The steam pressure was controlled by means of the other boilers in the station.

Efforts were directed toward securing a representative ash sample from each test for the purpose of determining the quantity of combustible in the refuse. In spite of the elaborate precautions which were taken, it is felt that at least in one instance the sample was not as representative as had been hoped for. This applied particularly to test No. 6 which shows a loss due to radiation and unaccounted-for of 8.3 per cent. It is believed that in this test the combustible in the refuse, as indicated in the table, was higher than actually found by analysis. Any one familiar with modern

stokers with large-size clinker pits will readily appreciate the difficulty of securing a truly representative sample, especially when cooling water is employed on the rolls and aprons, and the ashes are sluiced by hydraulic means. The ash samples for the determination of combustible were withdrawn just below the clinker rolls, and there was little difficulty involved while the spray water to the clinker rolls was not employed. However, at high rate of driving it was necessary to employ the spray water to protect the equipment, and it is possible that some of the finer particles of coke and cinder were washed out of the sample as it was being withdrawn.

In referring to the test data in Table 4 indicating the composition of the flue gases leaving the boiler and leaving the economizer, it is at once obvious that the casing and communicating ducts were tight. Due to past experience with air infiltration between the boiler and economizer outlet, special precautions were taken in the design of this equipment to eliminate the waste which results from this source. In the condensed summary of results, Table 5, the coefficient of heat transmission for the economizer is indicated, but for some reason tests Nos. 3 and 4 did not show performance in line with the other tests. It is felt, however, that this may be due to difficulties in measuring the gas temperature entering the economizer indicating a higher mean temperature difference than actually existed, but in any event the performance of the economizer from the heat-transfer standpoint appears very satisfactory.

Conclusions from Tests

Assuming the theoretical efficiency of a perfect boiler as 100 per cent, the efficiency ratios obtained by tests on these later

TABLE 4 COAL, FLUE-GAS, AND ASH ANALYSIS

Test No.	1	2	3	4	5	6
Rate of driving—Per cent of builder's rating	153	223	275	275	343	427
Proximate Analysis						
38 Moisture, per cent	5.87	4.61	5.05	5.20	5.85	5.48
39 Volatile matter, per cent	21.75	18.85	20.00	19.00	17.27	19.10
40 Fixed carbon, per cent	66.37	67.89	68.54	69.20	68.13	69.76
41 Ash, per cent	6.01	8.65	6.41	6.60	8.75	5.66
42 Fusion temperature of ash, deg. fahr.	2540	2675	2490	2780	2650	2592
B.T.U. Per Pound						
43 As fired	13840	13608	13940	13864	13397	13938
44 Dry	14704	14268	14681	14625	14223	14748
45 Combustible	15700	15690	15750	15710	15710	15690
Ultimate Analysis						
46 Sulphur, per cent	0.54	0.53	0.60	0.68	0.60	0.61
47 Hydrogen, per cent	4.53	4.42	4.48	4.45	4.32	4.51
48 Carbon, per cent	83.47	80.71	83.33	83.00	80.70	83.95
49 Nitrogen, per cent	1.21	1.22	1.23	1.19	1.25	1.19
50 Oxygen, per cent	3.87	4.04	3.61	3.79	3.83	3.78
51 Furnace refuse, per cent of coal fired (dry)	6.64	9.55	7.86	7.38	9.78	8.15
52 Combustible in furnace refuse, per cent	3.78	4.92	14.12	5.75	4.95	30.55
52a Carbon burned per lb. of coal	0.8322	0.8024	0.8221	0.9257	0.8022	0.8133
53 Carbon dioxide, per cent, boiler outlet	13.7	14.1	14.5	14.7	14.5	15.3
54 Oxygen, per cent, boiler outlet	5.2	4.9	4.3	4.2	4.4	3.2
55 Carbon monoxide, per cent, boiler outlet	0.1	0	0.3	0	0	0.4
56 Carbon dioxide, per cent, economizer outlet	13.2	13.4	14.0	13.6	13.8	14.9
57 Oxygen, per cent, econ. outlet	5.8	5.8	5.2	5.6	5.3	3.7
58 Carbon monoxide, per cent, economizer outlet	0.1	0	0	0	0	0.3
59 Ratio gas to coal by weight, boiler outlet	15.06	14.44	14.12	14.28	14.06	13.19
60 Ratio gas to coal by weight, economizer outlet	15.56	15.16	14.9	15.42	15.11	13.62
61 Excess air, per cent, boiler outlet	26.3	28.5	22.5	23.6	25.3	15.7
62 Excess air, per cent, economizer outlet	30.5	34.8	29.3	25.0	34.6	19.5

TABLE 5 CONDENSED SUMMARY OF RESULTS

Test number	1	2	3	4	5	6
Coefficient of heat transmission, economizer	7.53	7.45	6.03	6.44	7.82	7.53
Equivalent evaporation, boiler and superheater	66500	96700	119200	118800	148900	184040
Boiler horsepower developed, boiler and superheater	1930	2800	3460	3450	4300	5335
Per cent of rating, boiler and superheater	153	223	275	275	343	427
Equivalent evaporation, boiler, superheater and economizer	72500	105500	132800	132000	153400	205200
Boiler horsepower developed, boiler, superheater and economizer	2100	3050	3850	3830	4450	5950
B.t.u. liberated per cu. ft. of combination volume per hr	12850	17400	22150	22000	28190	37600
Efficiency of boiler and superheater combined	84.6	82.2	79.5	80.3	78.3	70.5
Efficiency of boiler, superheater and economizer combined	92.2	90.4	88.6	89.3	87.8	78.6

COMBINED HEAT BALANCE

	B.t.u.	%	B.t.u.	%	B.t.u.	%	B.t.u.	%	B.t.u.	%	B.t.u.	%
Heat per pound of dry coal	14704	100.0	14268	100.0	14681	100.0	14625	100.0	14223	100.0	14748	100.0
Heat absorbed by water in boiler	11330	77.1	10353	72.6	10360	70.6	10330	70.6	9650	67.8	9010	61.1
Heat absorbed by steam in superheater	1102	7.5	1375	9.6	1311	8.9	1423	9.7	1489	10.5	1381	9.4
Heat absorbed by water in economizer	1117	7.6	1164	8.2	1336	9.1	1316	9.0	1350	9.5	1194	8.1
Heat loss due to moisture in coal and combustion air	83	0.6	67	0.5	75	0.5	79	0.5	84	0.6	93	0.6
Heat loss due to water from combustion of hydrogen	450	3.1	444	3.1	465	3.2	455	3.1	443	3.1	570	3.9
Heat loss due to dry chimney gases	407	2.8	473	3.3	733	5.0	690	4.7	677	4.8	732	4.9
Heat loss due to escape of carbon monoxide	61	0.4	...	...	...	...	...	...	...	...	162	1.1
Heat loss due to combustible in furnace refuse	36	0.2	69	0.5	162	1.1	63	0.4	72	0.5	382	2.6
Heat loss due to radiation and unaccounted for	116	0.7	323	2.2	239	1.6	279	2.0	456	3.2	1223	8.3

Hell Gate boilers, superheaters, and furnaces run as high as 94 per cent. This is a ratio similar to the Rankine-cycle efficiency-ratio for a turbine. It is questionable, therefore, whether any considerable investment to improve this best-point efficiency is warranted. There remain, however, three important goals of endeavor. The first is to make the operating efficiency equal the test efficiency. This entails a perfect system of combustion control and a design requiring a minimum of maintenance. The second is to increase the range of high efficiency to allow of the accommodation to practical conditions of load variation and eliminations of banking losses. The third is to reduce the investment by increasing the overload capacity of the evaporating surfaces and coal-burning equipment, by reducing the furnace volume, and by more skilful design of the arrangement of apparatus.

Improvement of the Steam-Boiler Industry

AT PRESENT, American boiler manufacturing is passing through a trying period, which might be called the Period of Elimination because of excess of boiler-manufacturing capacity in this country.

In analyzing conditions, we find the causes for this excess to be centralization of power plants with consequent use of fewer and larger boilers operating at very high percentage of rating and high efficiency, also prime movers of high efficiency and better use of steam in process work. Other factors are development of water powers and use of oil and gas engines as prime movers, so that increase of boiler output has not been proportionate to growth of population or industries. These natural developments must be faced.

We should, however, follow the example of other industries in development of potential markets by trade extension; engineers should be shown that steel boilers are better than cast iron for heating, especially in larger plants such as institutions, factories, and apartments. Modernizing of industrial-power plants should be pushed in the interest of fuel conservation, for it is well recognized that, in 75 per cent of the boiler plants now operating, efficiency could be raised by amounts up to 30 per cent by replacing obsolete equipment with modern apparatus.

As to the future, I believe that there will be, before long, radical changes in boiler design and installation for central station and large industrial plants, necessitating changes in shop equipment. Centralization of power is here to stay and superpower is more than a phrase. Whether this will continue exclusively in the lines of public-service corporations or as centralized plants for a block, of neighboring industries, supplying power, light and heat for those industries and leaving general public service for the central station is a question for the future but, in my opinion, the latter is a logical development. (Geo. W. Bach, *Power Plant Engineering*, August, 1, 1926.)

The Problem of Steam-Boiler Corrosion[1]

Mechanism of Corrosion; Boiler Feedwater; Dissolved Oxygen and CO_2; Salt, Alkali, and Acid Content; Influence of Scale, Organic Matter, and Composition of Materials of Construction; Preventive Measures; General Precautions for Care of Boilers

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BEFORE considering ways and means for preventing corrosion in boilers, it is desirable to take an inventory of the more important facts which have been well established, with reference to the mechanism of corrosion in general.

The following seem to be the more important facts known at present regarding the corrosion of iron.[3]

1 It is well known that iron will not corrode at normal temperatures in the entire absence of moisture.

2 The presence of oxygen is also essential if appreciable corrosion is to take place in ordinary water. Oxygen and water alone will cause corrosion even in the absence of carbon dioxide or other acids. In natural water, corrosion is almost directly proportional to oxygen concentration, if other factors do not change. Oxygen also accelerates the corrosion of iron in dilute acid solutions.

3 Corrosion in acid is much more rapid than in neutral solutions, and the latter is more rapid than corrosion in alkaline solutions.

4 Hydrogen gas is usually evolved from the surface of the metal during corrosion in acid solutions, but the evolution is very much less in neutral and alkaline solutions.

5 The products of corrosion include, mainly, black or green ferrous rust which forms next to the metal, and reddish brown ferric rust which forms the outer layer, where sufficient free oxygen is present, with graded mixtures of the two in between. When iron corrodes in the atmosphere the amount of ferrous rust is small, but when formed under water, the ferrous rust often amounts to more than one-third of the corrosion products.

6 In corrosion in natural water the precipitated rust usually carries down some calcium, magnesium, and siliceous compounds, together with other insoluble material from the water. These substances have considerable influence on the structure and density of the rust coating on the metal surface.[4] If the rust coating is loose and non-adherent, under ordinary conditions the rate of corrosion may be accelerated locally but, on the other hand, if it is uniformly dense and adherent, it may cut down the rate of corrosion very considerably.

7 In most cases the initial rate of corrosion is much greater than the rate after a short period of time. This is particularly noticeable in alkaline solutions. As an exception, however, it should be noted that the initial rate of corrosion of a highly polished metal surface is abnormally low.

8 The corrosion rate increases with the concentration of certain neutral salts to a certain point and then decreases to a minimum at normal temperature, other things being equal. (At elevated temperatures, however, the rate does not seem to decrease with the concentration.) Dissolved salts often increase the tendency to pitting especially when they form protective coatings which are not continuous.

9 In natural waters the rate of corrosion generally tends to increase with increase in the velocity of motion of the water over the metal surface.

10 Composition of the iron, within the ordinary variations found commercially, has little or no effect on corrosion under water, but sometimes it has marked effect in atmospheric and acid corrosion. From the standpoint of corrosion, homogeneity of a metal is not usually so important as external conditions.

11 The condition of the metal surface in submerged corrosion may not affect the *total* corrosion, although it may have a marked tendency to *localize* the action and form pit holes.

12 Corrosion of iron is rarely uniform over the entire surface. Dissimilar metals in contact with each other, or with electrically conducting material in solution, tend to accelerate corrosion locally. This action is indicated by an electric current which flows through the solution from the more corrodible to the less corrodible material, i.e., from the anode to the cathode.[5]

13 Variation in concentration or in composition of solutions in contact with a metal tends to localize corrosion at certain areas of the surface (i.e., accelerate it) and retard the action at others. When a portion of the metal in solution is protected from diffusion of oxygen, it becomes anodic to other areas which are in contact with a solution richer in oxygen, i.e., corrosion is more active at such protected areas. The smaller the anodic areas with relation to the associated cathodic areas, the greater is the rate of corrosion at the anodic points and the greater the tendency for the formation of small holes or pits.

14 The solution under the porous cap of rust over active pits tends to become more concentrated in soluble salts. When a pit has gotten well started it seems to deepen at an increasing rate.

15 The polarity of a certain area is often reversed during the progress of natural corrosion, in which case, of course, pitting is not so pronounced.

In attempting to explain and correlate these facts which have been established by observation and experiment, the electrochemical theory has been developed. The name is derived from the fact that corrosion and many other chemical reactions usually produce an electric current which, however, is often very small. This is not to be confused with stray-current electrolysis due to electric currents external to the metal, although the damage done to the metal by the latter and the rust produced often have much the same appearance as in ordinary corrosion.

Before discussing boiler corrosion it may be well to picture the mechanism by which these reactions occur.

Mechanism of Corrosion

Iron, like all other materials, has a definite, inherent tendency to go into solution in water. The metal, however, can enter solution only by displacing some other element already in solution. For instance, a piece of iron placed in copper sulphate goes into solution, but at the same time copper is plated out and appears on the surface of the iron. In the ordinary case of iron immersed in water, hydrogen is the element plated out, and this element gathers on the surface of the iron in the form of a thin invisible film.

The presence of this film tends to obstruct or congest the progress of the reaction by insulating the metal from the solution. This interference may become so effective in natural waters as to stop corrosion altogether. Thus, the *first* stage of corrosion comes to a stop so quickly that no appreciable damage is done to the metal if the process goes no further.

In order that corrosion may proceed, the film of hydrogen must

[1] Presented before the Buffalo Convention, June 9, 1926, of the American Water Works Association.

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[3] This and some other of the contents of this article are taken from a book by the author and his collaborators entitled Corrosion—Causes and Prevention (McGraw-Hill Book Company, Inc., 1926), which contains further details on this subject.

[4] The term "coating" is used to designate a more or less continuous layer of solid matter on the surface of a metal. The term "film" is used to indicate a very thin coating consisting of either a liquid or a solid.

[5] A cathode is the pole of an electrolytic cell where current leaves the solution and enters the metal; an anode is the pole where current leaves the metal and enters solution. Anodes are sometimes spoken of as anodic areas or surfaces, and cathodes as cathodic areas. Anodic and cathodic areas may exist on a single piece of metal. The terms anodic and cathodic are often used in such a sense as: iron is anodic to copper. This means that if pieces of iron and copper in electrical contact are immersed in a solution of an electrolyte, the iron will act as anode and go into solution more rapidly, while the copper will act as cathode and will be less liable to enter solution. The terms "anodic" and "cathodic" are here employed instead of the terms "electropositive" and "electronegative," which are not always used in the same sense. In cases of corrosion of ferrous metals, iron is dissolved at the anode and hydrogen plated out at the cathode.

be removed. This can happen in two ways: either it may combine with oxygen in solution to form water, or it may escape as gaseous hydrogen.

Dissolved oxygen is usually present in water solutions, and removes the hydrogen film by reacting with it to form water. The process is then free to continue, that is to say, more iron can go into solution, more hydrogen can plate out, and the process can continue at a rate determined by the speed with which the oxygen removes the hydrogen. This is the *second* stage of corrosion and accounts for the continuance of the process in the great majority of cases.

In acids, the same reaction takes place. In addition to this, however, the tendency for hydrogen to plate out is much greater, and so much of it gathers on the metal surface that it is forced off in the form of hydrogen gas bubbles. Corrosion, therefore, is proportionately more rapid in acid solutions than in natural waters.

Ordinarily, the iron which goes into solution is thrown down as rust. After a time the rust, together with insoluble material from the water, may form a protective coating on the surface of the metal which interferes with the corrosion reactions by insulating the metal from the solution.

Important Factors in Steam-Boiler Corrosion

From the foregoing consideration of the mechanism of corrosion in general, it seems that corrosion in boilers is caused by two groups of contending forces. The first is the tendency of the metal to go into solution and is represented by its solution pressure. The inital corrosion thus started is maintained by the depolarizing effect of free oxygen and by the acidity (hydrogen-ion concentration) of the boiler water. The second group is made up of the protective or restraining influence of such factors as protective coatings deposited on the metal from the water, the polarizing effect of hydrogen in the absence of oxygen, the over-voltage of the metal to the discharge of hydrogen gas, alkalinity of the boiler water (low hydrogen-ion concentration), and the protective effect caused by contact with a more anodic metal (such as zinc), or through an externally applied counter-electromotive force. The corrosion products directly in contact with the metal on the evaporating surface of steam boilers have been found to consist mainly of the black magnetic oxide of iron (Fe_3O_4), with a larger proportion of the lower ferrous oxide when the oxygen is very low. The resultant of these and other influences determines the rate of corrosion under a certain set of conditions and, of course, the rate will usually vary if any of the essential factors are changed.

The most serious form of corrosion is when the action is concentrated on relatively small areas, resulting in pit holes. This is due to certain electrochemical reactions referred to above, by the action of which certain areas remain anodic to the rest of the surface. In this way the metal may be perforated before more than 5 or 10 per cent has been removed by rusting. The mechanism of pitting in boilers requires further investigation, but enough is known at present to make it practicable to minimize this trouble. The degree of prevention which may be economically applied, depends largely upon the cost of replacing corroded parts and the inconvenience and loss entailed by interruption or inefficiency in service.

Feedwater in General

All of the materials which constitute the earth's crust are more or less soluble in water. Their solubility is often greatly increased by the presence of carbon dioxide or alkalies in the soil water. Consequently, most natural waters are impure. Many of these are entirely unfit for boiler use without proper treatment. In some cases, a satisfactory water cannot be produced by treatment, and there is no other resource but to use distilled water or to find a more suitable supply. The use of poor quality water in high-pressure boilers leads to far-reaching difficulties when the water carries an undue amount of scale-forming or corrosive matter, and may result in the formation of heavy scale on tubes and plates and in corrosion of the boiler metal and equipment, sometimes accompanied by embrittlement of the metal. Operation under such conditions may result in tube failures (due to overheating or pitting), leakage, loss of heat, intermittent and unreliable operation of the plant, and large operating expense. Evidently the use of a good quality of water will greatly improve many of these items and, as a matter of experience, has usually proved to be a paying investment.

In a few localities, natural water is sufficiently pure to be used without treatment to remove incrustants, but no water should be used without treatment for the prevention of corrosion, although this may involve only the removal of a large portion of the dissolved gases. The higher the pressure, the more necessary it is that the water be as free from injurious impurities as possible. On the other hand, while heavy incrustants are undesirable from the standpoint of heat efficiency, the presence of a light deposit often affords considerable protection against corrosion. In the absence of any deposit, therefore, it becomes necessary to take all possible precautions against corrosion. For instance, rain water is highly corrosive, due to its acidity, high oxygen content, and lack of material which will form a protective deposit.

Dissolved Oxygen

A steam boiler in operation is a fairly efficient degasifier, and may liberate into the steam space most of the dissolved gases in the feedwater, particularly when evaporation is going on at a normal rate, and the feedwater is introduced above the water line. Where a light protective deposit is formed, it is not necessary that the dissolved oxygen and carbon dioxide of feedwater be reduced below a certain amount to prevent corrosion in the boiler proper. The amount of free oxygen in feedwater which will cause noticeable corrosion in steam boilers usually varies from 0.05 to 1 cc. per liter.[6] The amount permissible within these limits depends upon the acidity or alkalinity (hydrogen-ion concentration) of the water, and upon the nature of the feedwater, i.e., whether evaporated water or water containing incrusting salts is used. The feedwater should, of course, always be in the lower neutral or alkaline range.

Regardless of the theory of corrosion, experience indicates that the oxygen dissolved in the water is probably the greatest accelerator of corrosive action in boilers and accessories, and that it should be reduced to a certain minimum depending upon conditions.[7]

Carbon Dioxide

Carbon dioxide, either free or half-bound as bicarbonates of calcium and magnesium, is usually completely removed by water treatment, or partially removed in open feedwater heaters or deaerators. It has been shown that 35 per cent of the carbon dioxide of these bicarbonates is removed in a very short time when the water is completely deaerated under vacuum at from 140 to 160 deg. fahr. (60 to 71 deg. cent.), with the result that the pH value was increased from 6.7 in the raw water to 8.7 in the deaerated water.[8]

A small amount of carbon dioxide has little influence on boiler corrosion proper, but may cause serious corrosion to steam pipes and other steam auxiliaries. This occurs only where condensation of the steam takes place because dry steam has no action on iron below about 650 deg. fahr. (343 deg. cent.). However, where the water carries bicarbonates which have not been broken down with the elimination of carbon dioxide before the water enters the boilers, the boiler tubes may be severely attacked. Sometimes bicarbonate of iron is present. This and other bicarbonates can be partially decomposed and part of the gas separated in passing through an open heater operated at a temperature over 180 deg. fahr. (82 deg. cent.).

Due to the separation of carbon dioxide, it frequently happens that the boiler water is decidedly alkaline, while the steam gives an acid reaction.

Salt, Alkali, and Acid Content of Feedwater

It is a well-known fact that a certain amount of alkalinity will practically stop corrosion. *Higher alkalinity is required to inhibit corrosion with the higher concentrations of dissolved oxygen or of soluble salts* (Figs. 1 and 2). In distilled water, caustic alkalinity seems to

[6] This depends upon the design and operating conditions of boilers. In large units operating at high pressure with evaporated water, the feed should carry under 0.05 cc. per liter of oxygen at all times.

[7] The various types of apparatus which have been developed for removing this and other gases have been described in other papers by the author; Control of Corrosion by Deactivation of Water, *Journal Franklin Institute*, vol. 193, pp. 515–542, 1922, and Water Deactivation, *Proc.*, Eng. Soc. West. Pa., vol. 39, pp. 189–201, 1923.

[8] Jackson, D. H., and McDermet, J. R., Effect of Deaeration of Natural Waters on the Carbonate Equilibrium, *Ind. Eng. Chem.*, vol. 15, pp. 959–961, 1923.

have relatively more effect in reducing the corrosion rate as the temperature of the water increases. In high-pressure boilers using pure oxygen-free water, less alkalinity is required than is indicated by tests made at normal temperature when more oxygen is present. More experimental data are required to establish definitely this relation. At much higher concentrations caustic soda attacks the metal with generation of hydrogen and under certain rare water conditions this appears to cause embrittlement of the metal. Unless the dissolved oxygen in feedwater is under 1 cubic centimeter per liter, practical experience with stationary boilers shows that in most cases, the range of alkalinity which can be safely carried without causing foaming, or other trouble, will not prevent corrosion and pitting.

It has been shown that increase in pressure does not exert an appreciable effect on corrosion in water as long as the temperature,

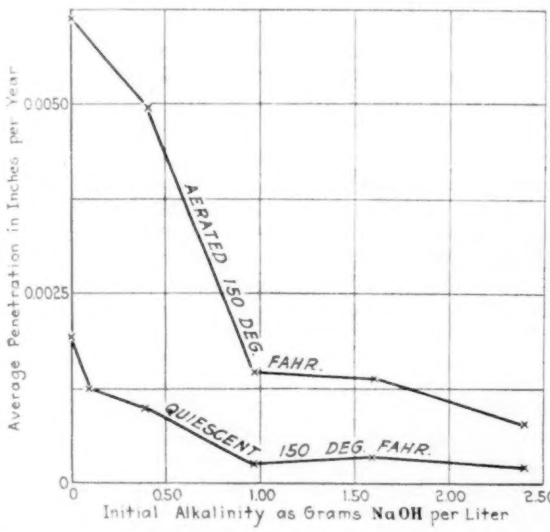

Fig. 1 Indicating Effect of Oxygen on Rate of Corrosion in Distilled Water of Different Alkalinities

(The quiescent water carried much less oxygen than the aerated water.)

oxygen concentration, and other factors do not change. As the concentration of soluble salts increases, the water becomes a better electrolyte and, if sufficient free oxygen is available, conditions become more favorable to the formation of pitting. The electrical conductivity of water also increases with the temperature. Furthermore, variations in concentration may give rise to concentration cells and localized corrosion (pitting). For these reasons, and to insure clean steam, it is desirable to maintain a relatively low and a fairly uniform concentration of soluble salts and alkalinity in the boiler water while under operation. These naturally increase rapidly when using a treated water, unless concentration is prevented by regular blow-downs.

Evidently the oxygen content, scale-forming properties, and the hydrogen-ion concentration (acidity or alkalinity) of the water are the main factors in boiler corrosion and are closely related. The hydrogen-ion concentration may usually be allowed to rise until the water is nearly neutral, if the oxygen content is zero, but with a lower hydrogen-ion concentration (more alkaline solution), somewhat higher oxygen is permissible, other things being equal. These factors may be balanced in any way that appears most economical within the limits of concentration which cause serious foaming. The minimum amount of hydroxide alkalinity required in any particular case should be determined by corrosion tests in service as this is dependent on many variables the effect of which cannot always be predicted.

Although water is generally rendered less corrosive by increasing its alkalinity, a certain degree of alkalinity increases the tendency to pit, and an excessive alkalinity in water free from sulphates seems to be associated with embrittlement of the steel in the boilers. Hence, it is important to establish and maintain a certain range of alkalinity, depending upon the composition of the water in the boiler and on operating conditions.

Experience shows that waters containing sodium chloride by itself are not necessarily corrosive, but that waters carrying magnesium chloride are usually corrosive under boiler conditions. Furthermore, magnesium chloride is regenerative in its action, so that once the salt is brought into the boiler the corrosive action proceeds in a cycle, as indicated by the following reactions:[9]

$$MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl \qquad [1]$$

$$Fe + 2HCl = FeCl_2 + H_2 \qquad [2]$$

$$FeCl_2 + Mg(OH)_2 = Fe(OH)_2 + MgCl_2 \qquad [3]$$

In this way the amount of magnesium chloride tends to increase by concentration of the boiler water. In the absence of free oxygen the action continues, but is much less rapid. Magnesium sulphate and sodium chloride form a corrosive mixture and interact in the boiler to form magnesium chloride. Nitrate of lime and magnesium, when concentrated in the boiler, may generate nitric acid in the absence of excess alkalinity by a cycle of reactions similar to the chlorides. Many of the salts which cause permanent hardness are also corrosive, so that the treatment required to reduce hardness and scale formation minimizes corrosion from this cause.

Acid boiler water usually originates from the drainage of mines, swampy land, and industrial waste, or from the decomposition of magnesium chloride, especially under high boiler temperatures and pressures. Occasionally, when the water supply comes from marshy localities covered with thick vegetation, the water is polluted with

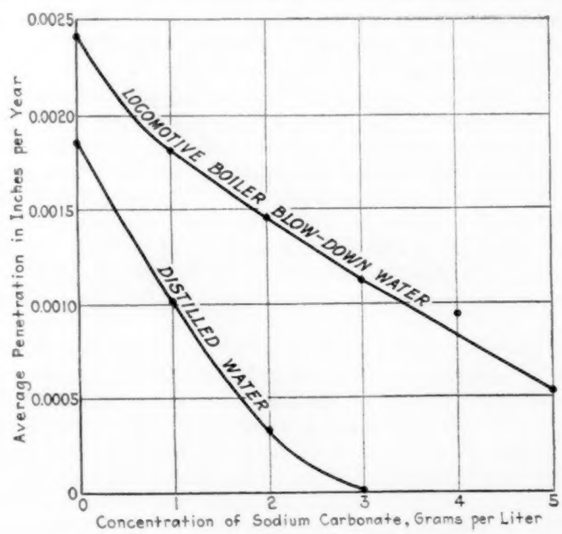

Fig. 2 Influence of Soluble Salts on Rate of Corrosion with Various Amounts of Alkalinity

Analysis of Blow-Down Water—P.p.m.

CaO	8.2	Alkalinity	255.3
SO_3	410.7	Carbonate	110.8
Total solids	1289.8	Hydrate	144.5

mixtures of organic acids. These are volatile and, unless fixed by the addition of lime or similar reagents added for that purpose, result in impure and corrosive steam. The alkali used for this purpose does not increase the alkalinity of the water in proportion to the amount added, due to combination with the organic matter, but the condensed steam from water so treated is no longer acid.

Sulphuric acid may be generated in the boiler where the water has been previously treated with coagulants, especially alum, unless sufficient alkali is added to form stable sulphates and leave a residual alkalinity of about 17 parts per million in the feedwater. Another source of acidity is from fatty acids derived from lubricating oil carried over to the heaters by steam from reciprocating engines using lubricants containing animal or vegetable oils. The decomposition of compounded lubricants takes place in a manner similar to that which occurs in the manufacture of soap from fats, liberating glycerine and fatty acids. The fatty acids are then free to attack the metal parts of the boiler. Since the animal or vegetable constituent is responsible for the corrosive action by lubricating oils, the best means of prevention is the use of lubricants having a pure mineral oil base. It should be borne in mind that it is just as important to

[9] The hydrogen in reaction [2] may be oxidized to form water or may escape as a gas. The chemical reactions in a steam boiler occur in such extremely dilute solutions that the laws of ionic reactions apply.

protect the boilers and accessories from the possibility of acid attack as it is to obtain perfect internal lubrication. The use of mineral oils for lubrication will also minimize the tendency for the boiler to foam with the production of wet and dirty steam. Fatty acids combined with alkalies to form soluble soaps, which, when present in a soft water or when associated with dissolved salts of sufficient concentration, may cause as much as 4 or 6 per cent of the feedwater to be carried over from the boiler with the steam.[10] When the raw feedwater carries free acid, it should be treated near the source with soda ash or lime so that it will carry about 15 parts per million alkalinity in terms of calcium carbonate, in which condition it will not seriously attack the pipe lines and pumps.

Influence of Scale

The protective influence of scale which forms on the metal below the water line is a factor which plays a very important part in boiler corrosion. Excessive boiler scale, however (particularly the sulphates and natural silicates), is objectionable, as it may greatly decrease the heat efficiency of the boiler and cause overheating of the tubes and shell. The presence of a more or less porous scale sometimes assists corrosion by increasing the temperature of the metal, producing a higher concentration of salts under the scale, and by favoring the decomposition of magnesium and other such compounds. For this reason, it is necessary in boiler-water treatment to consider both the control of scale formation and the removal of impurities which cause corrosion. Experience has shown that with an eggshell thickness of carbonate scale the oxygen contents of the boiler feedwater may be as high as 1 or 1.5 cubic centimeters per liter without serious damage to the boiler proper, but that with the use of 100 per cent evaporated water and no scale protection, a slight amount of corrosion is found even when the oxygen contents do not exceed 0.05 cubic centimeter per liter. A thin protective scale can be maintained, with a boiler water which otherwise would not form a protective scale, by the judicious addition of a certain amount of calcium hydroxide or sodium silicate. Such material should not be used unless the boiler water is tested regularly by a properly qualified operator.

In boilers, the corrosion that results from the decomposition of magnesium chloride, or other acid-forming salts, is the most serious because of the extensive pitting that often takes place underneath the scale before the corrosion is discovered. This action is sometimes exposed through cracks in the scale, which develop immediately over the affected areas due to the increase in volume of the products of corrosion. Where sufficiently pure water is not available, it is important that proper treatment be used to completely eliminate all scale-forming and corrosive compounds and to maintain the correct balance between alkalinity and the other substances in solution.

Artificial protective coatings, such as special paints, afford only temporary protection to metal in contact with water at boiler temperatures. Any breaks in the coating tend to concentrate the action of the water at such places, so that if such coatings are used, they should be inspected at frequent intervals.

Organic Matter

It has been observed in practice that corrosion does not always occur when the feedwater is untreated, and, as pointed out by Newman,[11] it seems to be less noticeable and, in fact, in some cases entirely absent where the organic content of the water is relatively high and where laboratory tests indicate a high consumption of oxygen by dissolved organic matter in the water.

The alkaline tannates, properly adjusted, are said to have the property of combining with dissolved gases, particularly with oxygen.[12] It has been stated that organic matter tends to prevent the decomposition of soda ash in boilers.[13] A few tests in a laboratory boiler did not show this retardation with tannic acid or sugar.[14]

[10] Bradshaw, *Proc.*, Eng. Soc. Western Pa., January, 1925.
[11] Abstract of discussion by M. F. Newman of paper by F. N. Speller, Water Deactivation, *Proc.*, Eng. Soc. Western Pa., vol. 39, pp. 189–201, 1923.
[12] French, D. K., Internal Treatment of Boiler Water—Proper and Improper, *Ind. Eng. Chem.*, vol. 15, pp. 1239–1243, 1923.
[13] Rice, Cyrus Wm., private communication.
[14] Karch, H. S., and Hall, R. E., private communication.

Influence of Composition of the Materials of Construction

Charcoal iron and low-carbon bessemer and open-hearth steels have been used for boiler construction with very little difference in the rate of corrosion or pitting. Bessemer steel, however, is not now used in important parts of boiler construction on account of the tendency to develop brittleness in service as a result of fatigue. It is difficult and costly at present to make boiler tubes of corrosion-resistant metals, such as high-chromium iron or the nickel-chromium alloys. Until tubes can be made of a material decidedly better than low-carbon basic open-hearth steel, there will be little advantage in making other parts of the boilers of these more expensive steels, as the tubes are the vulnerable parts and usually the first to fail. It seems at present, therefore, that the solution of the corrosion problem in boilers lies in the removal or control of the causes of corrosion. Generally speaking, this is not a very difficult problem.

Preventive Measures

Boiler-water treatment in general.[15] Some of the harmful gases in boiler feedwater are driven off by heating in feedwater heaters or deaerators, but others can only be removed by chemical treatment. The best control over boiler water is naturally obtained by the use of evaporators and distilled water (with deaeration) but there are, of course, many places where this practice is impracticable or unnecessary. In modern, high-pressure stationary steam plants, however, the difficulties due to poor quality water are so serious that the use of distilled water, with every precaution for excluding air from the system, is becoming more general. In fact, where high-pressure stationary boilers are operated at 200 per cent rating or higher, a water free from incrustants is considered to be necessary. Under these conditions, where the percentage of make-up water in the feed supply is small, it usually pays to install evaporators.

In smaller plants, operating below 150 pounds pressure and at low rating, it is sometimes most economical to treat the water on its way to the boiler and carry out the reactions in the boiler itself, thus avoiding the expense of boiler-water treating equipment. When the precipitated matter which results from internal treatment of feedwater causes an undesirable amount of water in the steam, the additions should be made and the reactions completed outside of the boiler. The equipment for external treatment should be of sufficient capacity to permit the maximum precipitation and separation of suspended matter and scale-forming and corroding compounds before the water enters the boiler. In most cases, sufficient saving can be shown in increased efficiency of operation to warrant external treatment by one of the systems developed for this purpose. The basic principles of these systems involve the use of lime and soda ash, or some similar chemical, and the results obtained have been well-established and proved by experience.

In general, a properly softened boiler feedwater is one in which there is no permanent hardness, in which the calcium and magnesium carbonates have been reduced to a minimum, and in which the total alkalinity (by methyl orange), due to sodium carbonate and hydroxide, is from 25 to 50 parts per million (according to the temperature of the treating tanks).

The water should be treated to eliminate unstable salts of magnesium or calcium and should carry sufficient excess of total alkalinity to prevent the formation of corrosive acids in the boiler. Alkalinity, due to calcium carbonate, is not sufficient to prevent acid corrosion, as it will not stop the decomposition of magnesium chloride, or of calcium chloride formed by the interaction of calcium carbonate and magnesium chloride. In such cases, full protection against corrosion can be obtained only by the application of a soda-ash treatment to convert the magnesium chloride to the neutral and stable sodium chloride.

In stationary and locomotive practice, it has usually been found economical to remove scale-forming and corrosive matter from the feedwater before it enters the boiler. This may be done in nearly every case by the use of soda ash and lime, either by the intermittent or by the continuous process.

[15] This section is not intended to cover all details of boiler-water treatment. As prevention of scale and corrosion are closely allied subjects, however, they are outlined together. Further details may be had by reference to the methods of procedure recommended in Suggested Rules for the Care of Steam Boilers in Service, A.S.M.E. Boiler Code, Sec. 7.

The recommended procedure for obtaining the proper chemical treatment of a boiler feedwater is to: (*a*) make a complete technical analysis of the feedwater; (*b*) determine the amount and kind of treating chemicals required and the best system of treatment, and (*c*) procure reagents and apparatus for carrying out the treatment and making the necessary control tests. This requires the services of an experienced industrial-water chemist.

Passivifying agents, such as the chromates, are not adapted for boiler use as passivity is destroyed by heat. Furthermore, the chromates react with soluble chlorides to produce free hydrochloric acid, so that in some natural waters their use might cause acid steam.

Boiler compounds of unknown composition should not be used for the treatment of boiler water. The basis of any successful treatment is a detailed knowledge of the objectionable materials in the water and the influence of the products of the treatment on the operation of the boiler and the quality of the steam. The recommendation of experienced concerns who manufacture boiler-water compounds may be helpful after they have had an opportunity to examine analyses of the water requiring treatment.

Special application of water treatment to various kinds of steam boilers. While the general conditions which cause corrosion in boilers may frequently be the same, there are three main fields of boiler service and treatment which vary sufficiently from each other in practice to warrant separate discussion in respect to some details. These are found in the treatment of water for stationary, locomotive, and marine boilers.

The previous discussion applies to boiler practice in general. The problem in the case of stationary boilers, however, is not usually complicated by having to obtain feedwater from a number of sources as in locomotive and marine practice, so that the treatment is comparatively easy to control. Hence, it is not surprising to find that, as a rule, much better results are obtained in stationary practice than in other classes of boiler service.

Deaeration of feedwater has been well developed for stationary-boiler practice and in most cases, so far as the boiler itself is concerned, sufficiently good results will be obtained by the use of properly vented, open feedwater heaters of sufficient capacity.

The position at which the feedwater is introduced into the boiler has a marked influence on corrosion. It is much better to release the feedwater a little above the high-water level, so that it flows lengthwise in a long open tray or over pans placed in the steam drum. This further preheats the water to some extent and gives the dissolved gases an opportunity to be released into the steam space before the new water has time to diffuse downward in the boiler and to come in contact with the metal. Where such apparatus is omitted or not properly installed, the oxygen immediately below the feedwater entrance is higher than elsewhere in the boiler. This, with the greater circulation downwards immediately below the feed entrance, causes greater corrosion on these tubes than elsewhere in the boiler.

Although the temperature of feedwater is much lower than in the boiler water, pipes carrying hot feedwater to the boiler are usually much more subject to corrosion than the boiler tubes, due to the relatively higher oxygen contents of the feedwater. If the feedwater inlet is so placed as to permit the water to impinge on any metal part of the boiler, rapid corrosion is certain to occur at such places unless the water is free from dissolved oxygen.

The velocity of circulation in a high-pressure boiler is very high. While most of the oxygen is discharged in the steam drum, some of it will be carried along with the boiler water, and will cause corrosion. Feedwater carrying dissolved oxygen should not be added to a boiler which is not steaming as it will diffuse through the boiler and cause corrosion. The water in a boiler should, therefore, be brought up to the proper level while it is in operation.

The viscosity of water decreases considerably with increase in temperature. This, with the high velocities of water in modern boilers operating under high rating, probably tends to increase corrosion by bringing the main body of the water into closer contact with the metal, thus sweeping away surface films (liquid and solid) which otherwise might exert a marked protective effect.

Steam in the absence of oxygen. Steam in the absence of oxygen attacks iron to a very slight extent at 650 deg. fahr. (343 deg. cent.). The action increases rapidly with the temperature so that serious damage may result in time at temperatures around 1200 deg. fahr. (649 deg. cent.). It has even been shown that in steam boilers, with an oxygen concentration in the water of less than 0.1 cubic centimeter per liter, a small amount of gaseous hydrogen (under 0.1 cubic centimeter per liter) is evolved at a temperature of 585 deg. fahr. (308 deg. cent.). The amount of gaseous hydrogen evolved increases with the temperature within certain limits not yet fully defined. In this connection it is interesting to note that pure water at 650 deg. fahr. (343 deg. cent.) has a pH of 5.5.

The action of steam on iron at high temperatures produces magnetic oxide of iron according to the reaction:

$$3Fe + 4H_2O = Fe_3O_4 + 4H_2$$

This is becoming a more important practical consideration, due to the present tendency toward higher pressures and superheating in modern steam power plants. Already signs of deterioration have been observed in steel superheater tubes. It has been found that steel, wrought iron, malleable iron, and white and gray cast iron are all subject to attack, but the high chromium and nickel-chromium-iron alloys are much more resistant under these conditions.

Superheaters. For iron pipes which convey pure dry steam, and are not externally heated, experience indicates that no deterioration of the metal is to be feared up to 1000 deg. fahr. (538 deg. cent.), or probably a little higher. For conditions where heat is being transferred to the steam (as in superheater units), and where the tubing is not subjected to high gas temperatures at times when no steam is flowing through the tubing, seamless-steel tubing has shown practically no oxidation up to 800 deg. fahr. (427 deg. cent.) steam temperature. The extent of deterioration of pipe at high temperatures also depends upon other variables such as: the amount of excess air in the products of combustion, the amount of corrosive sulphur compounds in the gases, the velocity and temperature of the gases, the impingement of flame, and the abrasion due to solid particles in the gas stream. These factors at the present time are responsible for much more deterioration than the temperature of the steam.

Locomotive practice. The design and construction of locomotive boilers, the composition of materials entering into their construction, and their mechanical operation, have reached a high stage of development. The chemical and physical properties of the plates and tubes used are so regulated by rigid specifications that the quality of the material is well above the average. The development of improved steel may have had some influence in prolonging the life of locomotive tubes, which are naturally the vulnerable part of the boiler. It must not be forgotten, however, that locomotive boiler service is usually the most severe of all. The treatment of locomotive water to stop corrosion is more difficult to control and is complicated by factors not present in stationary-boiler practice. The alkalinity cannot usually be carried high enough to inhibit corrosion when the water is high in oxygen without causing foaming, and so far no practical apparatus has been developed to eliminate enough of the free oxygen from locomotive feedwater to stop corrosion. It has been frequently noticed that stationary boilers show no pitting or corrosion after 15 years or more, whereas locomotive boilers, using the same water, may show serious pitting after 2 or 3 years.

Boiler corrosion may be practically eliminated as a general rule if the hydroxide alkalinity is kept over 100 parts per million and the oxygen content of the feedwater is reduced to 1 cubic centimeter per liter or lower. As pointed out above, this degree of deaeration is usually accomplished by open heaters with stationary boilers, but the application of this type of heater or deaerator to locomotive service presents serious practical difficulties. Any feedwater heating or deaerating apparatus designed for locomotive use must, of course, be comparatively small and compact, and should heat all the water up to the boiling point or higher. So far feedwater heaters for locomotive service have been designed mainly to give greater thermal efficiency. With this may be combined an important increase in the life of boiler tubes if a considerable portion of the air is removed. A practical form of locomotive feedwater heater is badly needed; one which will not leave more than 1 cc. per liter of dissolved oxygen in the feedwater is required.

Some experiments conducted by the author with the use of a vacuum deaerating tank in the tender of a locomotive resulted in the removal of 35 per cent of the oxygen from the feedwater at

76 deg. fahr. (24 deg. cent.) with a vacuum of 8 inches of mercury. Under these conditions, there was a residual oxygen content of 4 cubic centimeters per liter. It was found that to reduce the oxygen to 1 cubic centimeter per liter a vacuum of 20 inches and a temperature of 125 deg. fahr. (52 deg. cent.) would have to be carried. It was found impractical, however, to start an injector in operation at a temperature as high as 100 deg. fahr. (38 deg. cent.) with a vacuum of over 4 or 5 inches so that for this purpose a feedwater pump seems necessary whether the water is deaerated in an open heater at the boiling point under atmospheric pressure, or in a deaerator at a lower temperature and pressure.

As pointed out above, the position at which the feedwater is introduced into the boiler has an important bearing on the proportion of the free oxygen which is retained in the water and is available for corrosion of the boiler. This point should receive careful consideration in connection with locomotive boilers where the feedwater is usually delivered to the boiler nearly saturated with oxygen.

Although locomotive boilers are subject to a much wider variety of water and more strenuous service than stationary boilers, as a rule less attention is given to water treatment, particularly by the smaller railroads. This is also true with respect to the development of feedwater heating and deaeration which is so essential and might easily treble the life of locomotive boiler material.

Other General Precautions for Care of Boilers

Water treatment for new boilers. During the construction and installation of new boilers, more or less grease finds its way into the plates and tubes. This should be removed by adding $2^1/_2$ pounds of soda ash per 1000 gallons of water and boiling with a slow fire at atmospheric pressure for a period of at least 48 hours. After emptying the boilers they should be thoroughly washed out with clean water applied by a hose at high pressure.

The clean unprotected metal is likely to corrode rapidly as, for example, in new boilers or in boilers which have been re-tubed or turbined. After the boilers have been thoroughly cleaned, by the above method, about 10 pounds of lime for every 30,000 pounds water capacity should be mixed with the cold feedwater and run into the boiler, and from 4 to 6 pounds of lime, as milk of lime, for every 30,000 pounds water capacity should be added each day for not longer than six days. Milk of lime is a mixture of about 1 pound of unslaked lime, or $1^1/_3$ pounds of hydrated lime, with 1 gallon of water. Lime additions are made, as a rule, only when the boilers are new or after re-tubing. The lime treatment should be completed before any other treatment is applied to the water. Lime is soluble to about 90 parts per million at 200 pounds boiler pressure (382 deg. fahr.), so that the excess over this amount will be deposited as a soft scale on the metal or as sludge.

The action of the water is concentrated on areas from which the mill scale has been removed and, if this is a small proportion of the whole surface, pitting may result. More uniform corrosion and longer life of the tubes may be obtained by first pickling them free from scale, and then washing them in warm water and in milk of lime before they are installed.

Internal protection. When boilers are first filled the water should be boiled under atmospheric pressure using a direct fire and agitating the water by means of circulators or, in the absence of circulators, the water should be simply boiled for a short time under atmospheric pressure before the boilers are closed.

Pump glands in suction lines should be tight enough to avoid drawing in air. All feed-pump suctions should be entirely covered with water at all times, and all discharge lines should be scaled.

If all oil cannot be removed from the feedwater by mechanical means, the lubricating oil should be analyzed for fatty compounds, and if these are present, straight mineral oil should be substituted.

Defective circulation and unequal strains in the boiler metal tend to promote local corrosion.

Electrolytic action often occurs where copper and brass pipe or fittings are fastened to the boiler structure or where copper ferrules are used, and this may cause local accelerated action on the steel unless an insulating scale is formed by the water.

Where pitting has occurred, the pit holes should be thoroughly cleaned out and filled in with zinc oxide paste. Where only a small number of deep pits occur, these may be cleaned and filled in by electric or acetylene welding, when this practice is not prohibited by insurance or other regulations.

The boiler should be blown down as often as necessary to keep the concentration of dissolved salts fairly uniform and at a safe value. When the boilers are taken out of service, certain precautions should be taken to prevent corrosion. They should be emptied and dried by means of a light wood fire. About 20 pounds of quicklime for each 100 horsepower should be placed on wooden trays in the interior of the boiler, after which all connections should be tightly sealed. Where the boilers are idle for a considerable period they should be opened every 3 months for examination and renewal of the lime. If water is left in idle boilers it should be made alkaline with caustic soda in excess of 50 grains per gallon and the water level should be raised up to the safety valve. The number of pounds of soda required equals the rated horsepower multiplied by 0.7. Caustic soda should be first dissolved and then added through the top main header into a full boiler of water, after which all openings and connections should be made tight. A piece of bright iron should be hung in the boiler in such a manner that it can be removed and inspected at regular intervals to determine whether or not the treatment is sufficient to stop corrosion.

Conclusions

The more important preventive measures which may be applied to protection of steam boilers may be summarized as follows:

1 Reduction of free oxygen to the lowest limit practicable. This combined with the right alkalinity has an important bearing on the control of the tendency of metal to corrode and pit.

2 The maintenance of a sufficient amount of hydroxide alkalinity to prevent corrosion and pitting. The amount required decreases as the residual free oxygen is reduced, and is also dependent on the concentration and kind of salts in solution. As there are so many factors involved, the correct alkalinity required should be determined, for the present, by tests on concentrated boiler water under service conditions as nearly as possible.

3 The scale-forming salts should be kept under control by proper water treatment so as to give only a light protective scale; pitting sometimes occurs under certain kinds of thick scale. Proper treatment of the water when the boiler is first filled is particularly important to avoid initial corrosion.

4 The best grade of material should be employed throughout. The tubes should preferably be pickled free from rust and mill scale, and washed in milk of lime before installing.

5 A counter-electromotive force may be imposed on the parts to be protected (as by the Cumberland system or by firmly attaching zinc slabs to the boiler shell), but these expedients present some mechanical difficulties in application and unless properly installed and maintained are of little or no use.

6 As dissimilar metals in contact tend to accelerate the corrosion of the one that happens to be anodic, and retard the action on the other proportionately, it is preferable, where corrosion cannot be entirely prevented, to have important parts cathodic to other parts the corrosion of which is not such a serious matter. It is especially desirable to avoid using an anodic or electropositive metal for small parts such as rivets as the action in such cases will be concentrated on a relatively small area and may cause serious results in a comparatively short time, whereas when the larger area is the anode the depth of penetration in a given time will be extended in proportion to the relative areas of the surfaces in contact. Copper-bearing steel is slightly cathodic (or electronegative) to non-copper-bearing steel and may be useful in certain cases, such as for rivets or tubes, where it is desirable to control the relative potential of the various parts of the boiler. The author has found low-carbon steel carrying 0.5 to 1 per cent copper to be much more resistant than soft steel of lower copper contents, in certain kinds of highly concentrated salt water. As this alloy is not very expensive and has good physical properties, it may find a useful application in boiler construction.

7 The water treatment should have sufficient expert supervision with analyses at regular intervals and check corrosion tests on samples inserted in the boiler.

From the foregoing review of the facts and factors involved in steam-boiler corrosion, it seems that deterioration from this cause can usually be controlled at a reasonable expenditure, under proper supervision. Compared with the amount invested in steam power

plants, the extra outlay required to minimize or prevent corrosion is usually a relatively small item and one on which a relatively large return may be expected.

Much has been done during the past ten years in the study of the many factors involved in corrosion. It has been found that the ordinary variations in composition of iron or steel and other factors inherent to the metal, such as strain, grain size, metal structure, etc., are of minor importance compared with the influence of dissolved oxygen, the contact of dissimilar materials or solutions, and many other factors external to the metal. It has also been shown that corrosion may be classified into several different types, each one being controlled by a different set of external factors so that the problem as a whole is evidently very complex. In any one type of corrosion, however, such as in steam boilers, it appears that only a few factors exert a controlling influence. It may be expected therefore that much more progress will be made in the practical solution of the corrosion problem as a whole, when those most interested in each phase of the subject arrange to organize their investigation work together under the control of a responsible working committee. The committee which has been organized by the American Water Works Association, with the coöperation of the American Railway Engineering Association, National Electric Light Association, and The American Society of Mechanical Engineers, for the study of boiler feedwater treatment would seem to be the natural sponsor for this phase of the work. The actual research work in the laboratory and in the field should be done by competent assistants who can devote their *entire time* to working out the details of the plan of investigation. The refrigerating industry has recently started a systematic investigation of its corrosion problems in this way and already the results of this concentrated effort point toward a practical solution of many of these problems. As a fundamental step towards the solution of the corrosion problem with respect to locomotive and stationary boilers, the following suggestions are offered: (1) that this problem be placed in the hands of an active committee who will be strongly sponsored and supported; (2) a definite working program should be laid out involving a study of the work already done, new laboratory research (particularly on the pitting of iron), and the testing of preventive measures in practice; (3) sufficient funds should be raised to carry out such a program over a period of at least three years. It is the belief of the writer that with such an organized effort much may be accomplished towards a practical and economical solution of this problem.

Considering the great economic loss due to corrosion and the general interest in this subject, it would seem logical and most economical for each of the large industries interested to appoint responsible working committees with experienced assistants as suggested above, and then tie these committees together by means of a central advisory committee so as to pool all the results and avoid overlapping of research work. In this way it seems that the best results may be expected with the least expenditure of time and money.

Water-Treating Problems Encountered in Railroad Practice

BY S. C. JOHNSON[1]

OF THE 350 billion gallons of water now being used annually for steam purposes on American railroads, it is estimated that 50 billion, or about 15 per cent, are receiving treatment in some form. At a general average cost of 4 cents per 1000 gallons for treatment, the yearly operation expense is in the neighborhood of $2,000,000. There are approximately 1200 water stations out of a total of 16,000, where chemicals are added and the total investment in softening plants, including the inexpensive as well as the elaborate types, is at least $10,000,000. It is estimated that these plants are removing 100,000,000 lb. of scale-forming solids annually, which, if allowed to enter the locomotive boilers would represent an additional expense in locomotive operation and maintenance of approximately $13,000,000.

[1] Chief Chemist, Water Supply Department, Chesapeake and Ohio Railway System.

Abridged from a paper presented at the Annual Meeting, Buffalo, N. Y., June 9, 1926, of the American Water Works Association.

DEVELOPMENT OF WATER TREATMENT

The development of water treatment on American railroads has received its greatest attention on Middle-Western systems where the objectionable quality of the natural waters was such that some form of treatment early became an operating necessity. Possibly because of practicability, or lack of research work or information on this subject, efforts toward correction were confined at first to internal treatment, principally with so-called "boiler compounds" or "metal treatment" with secret formulas.

The next development was in the application of soda ash, both direct in the boiler or at wayside tanks. However, the precipitate formed by this reaction is so finely divided that the sludge in the boilers, together with the increase in alkali-salt concentration, causes serious foaming conditions and the system has been found objectionable unless followed up with careful supervision to insure the boilers being blown down sufficiently to maintain the concentration within workable limits.

The systematic treatment with soda ash at wayside tanks appears first to have been developed on the C.B.&Q.R.R. and later extended to the Wabash, Frisco, and the Alton, and several other roads are using it to some extent. The method consists in treating all waters, where necessary, to insure an excess of about two grains per gallon sodium carbonate. Frequent check is made of samples from locomotive boilers and effort is made to maintain approximately 15 per cent of the total dissolved solids as sodium carbonate. This internal inspection is also necessary to insure sufficiently frequent blowing to keep the total dissolved solids below 125 grains per gallon in order to prevent foaming delays. Where sufficient supervision is provided to insure the carrying out of the predetermined practice, very satisfactory results have been secured. However, the necessity for the careful check and follow-up of the locomotive operation presents such difficulties that the extension of this system has been somewhat limited.

Experiments with zeolite softening for railway service have not been altogether satisfactory although tests being made at the present time on the Western coast indicate possible success with certain types of water. The preponderance of surface supplies with their occasional high content of suspended matter, limit the scope of this system as well as the dissolved solids quality, unless prefiltration is provided, with additional expense for installation and maintenance.

STANDARD METHODS NOW IN USE

The standard and usual method of complete railway water softening now practiced consists in the addition of lime and soda ash to the water in predetermined amounts at wayside settling tanks. Its object is not only to soften the water but also to remove the precipitated sludge with mud or suspended matter, so as to deliver the waters to the boilers not only soft but clean.

The lime and soda process of treatment in railway service has developed from the simple intermittent system which consisted merely of two or more tanks which were filled, treated and used alternately, through the intricate proportioning devices with continuous automatic proportioning, back to the more sensible and simple continuous systems. The chief essentials are proper chemical proportioning and sufficient mixing and reaction time followed by sedimentation and clarification before delivery of water for use.

Many intermittent systems are still in use and the capacity of treating tanks varies from 10,000 gallons to 500,000 gallons, but the governing principle is the same and similar satisfactory results can be secured. The usual means of agitation is by compressed air, which is a more flexible and more easily maintained system than the mechanical agitators which have been tried.

Plants of the continuous type consist of large tanks, usually of steel, with inside tubes of sufficient size to retain the water during the mixing and reaction period of from 30 to 45 minutes. The water and chemicals are mixed in these tubes in continuous proportion, flowing from the mixing tube to the bottom of the sedimentation tank from which they rise to a predetermined point before the clear water is drawn off for service. The specific gravity of the precipitated sludge is sufficiently greater than water to permit complete clarification in five hours if the vertical velocity of the settling water does not exceed 8 feet per hour, provided, of course, that the proper amounts of chemicals have been added to insure complete reaction and unbalanced equilibrium avoided. If clarification

troubles are experienced, filters are sometimes provided which usually consist of matted excelsior at the top of the sedimentation tank, although there are a number of plants in service with gravity or pressure sand filters. Some experimenting is again being done with the elimination of the downtake tube and merely running the chemicals and water together without special mixing or agitation at the bottom of the sedimentation tank, although experience with this system some years ago was not entirely satisfactory.

In any system of water softening for railroads, the largest single factor in securing satisfactory results lies in competent and interested supervision. The chemical quality of the raw water and softened water should not only be checked at frequent intervals but inspection should also be made of the mechanical facilities to insure dependable and uninterrupted service. On railroads where treatment is practiced to any appreciable extent, systematic methods are therefore necessary to permit the handling of the situation with minimum force.

Savings

The savings which are possible through improvement in quality of railroad water supplies is necessarily dependent upon local conditions. In 1914, the American Railway Engineering Association presented figures to show that the cost of each pound of incrusting matter permitted to enter the locomotive boiler in such condition that it could deposit as scale on the tubes and sheets, was 7 cents, considering only the effect on fuel consumption, boiler and roundhouse repairs, and engine time. This figure, transposed to present-day prices, is 13 cents. Study by a special committee of the American Railway Engineering Association for the past five years has found that the statistics which have been gathered indicate that this figure is conservative. There is no question but that, with proper treatment of the water, scale and pitting conditions, with their incident boiler-maintenance expense, can be largely eliminated and that the fuel consumption in clean and dry boilers is much less than with leaky or badly scaled power.

On the Chesapeake and Ohio Railway, during 1925, there were 30 water-softening plants in service at the 207 water stations. Of these 30 plants, 23 were of the continuous type, 2 intermittent, and 5 of the simple soda-ash system. Of the 6,135,922,000 gallons of water used for steam purposes, 2,496,038,000 gallons, or 40.7 per cent, were treated and a total of 2,672,080 pounds of injurious scaling and corrosive matter removed before the water was delivered for steam boiler use. The total cost for chemical treatment, including operation, maintenance, interest, and depreciation, was \$103,715 or an average of 4.5 cents per 1000 gallons, but the cost for chemicals alone only averaged 1.98 cents. The estimated net saving for the year by reason of this treatment amounted to \$243,675 which represents 67.2 per cent on the \$356,323 invested in water-treating facilities. This estimated saving averages but \$480.00 per locomotive using the treated water which is a conservative rating.

Progress of Water Treatment on Railroads

BY R. E. COUGHLAN,[1] CHICAGO, ILL.

ON THE Chicago and North Western Railway, practically all of the water supplied to boilers, except that obtained from lakes and rivers of northern Wisconsin and northern Michigan, require treatment. Partial treatment and internal treatment have been used for many years. An extensive water-treatment program was started in 1903 when sixteen lime and soda-ash treating plants were built in Iowa, where the water is hard, due to the large quantity of sulphates of magnesia and lime contained in solution. These were the pioneer water-softening plants in that section of the country, and have been added to from time to time, until at present there are forty-seven lime and soda-ash water softeners in operation, and ten more under construction. These are supplemented by partial treatment and internal treatment where local conditions warrant it. Intermittent types of softeners were the first installations.

In 1922, the first continuous type softener was installed.

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Abridged from a paper presented at the Annual Meeting, Buffalo, N. Y., June 9, 1926, of the American Water Works Association.

The boiler-failures report of the C.&N.W. Ry. Co., for 1910 shows 2132 failures, chargeable to water conditions. The same report for 1925 shows 37 failures. The monthly boiler-failure report for February, 1910, and February, 1926, is as follows:

BOILER-FAILURE REPORT FOR MONTHS OF FEBRUARY, 1910 AND 1926

Cause of failure	Feb., 1910	Feb., 1926
Leaking flues	319	0
Leaking fireboxes	22	0
Leaking arch tubes	0	0
Flues burst	3	0
Arch tubes burst	30	0
Foaming	17	0
Total	394	0

The C.&N.W. Ry. now operates locomotives in passenger service from Clinton, Iowa, to Omaha, Nebraska, a distance of 350 miles. These locomotives make a round trip of 700 miles each day. Another western railroad operates locomotives in passenger service 600 miles without change, while still another has completed test runs of over 1700 miles, one locomotive pulling the train the entire distance.

With the problem of incrustation of boilers practically under control, more attention is now being given to the pitting of flues and the corrosion of boiler sheet. Many theories as to the cause of this trouble have confused the issue. Many committees have held symposiums on the subject. The railroad water-service engineers have not been idle, although their work has been somewhat hampered, due to incomplete records and the increasing evaporating power of boilers. When it was found that removing the scale did not prevent corrosion, further studies have been made along three special lines, namely: (1) use of feedwater heaters to eliminate oxygen; (2) counter-electrical potential devices; (3) excess treatment.

The first two of these methods are still in the experimental stage, each method having its respective merits and adherents. The excess-treatment method has shown great possibilities where it is practicable to apply it in the railroad service. This method, proved in the laboratory, consists in the addition of an excess of caustic soda, caustic lime, or sodium carbonate over that required to combine with the scale forming salts. The success of this treatment depends upon uniformity of treatment over an entire locomotive district to prevent foaming.

Where it is possible to secure this uniformity, high concentrations of alkaline salts are carried in the boilers with practically no foam trouble.

The C.&N.W. Ry. Co. has a locomotive district where 50 per cent of the natural water contains over 50 grains of sodium carbonate per gallon. By treatment of the remaining water to a similar composition, a concentration of over 8 per cent normal, alkalinity is carried without trouble. Pitting and corrosion are unknown in this district and, needless to say, the boilers are clean. Additional lime and soda-ash softeners are being installed in other locomotive districts as rapidly as funds become available, so that in a short time, this method of treatment will be in general use.

One of the railroads having 71 lime and soda-ash softeners in operation is treating water to less than 1 grain per gallon hardness, leaving in the water an excess of lime and soda ash for the purpose of eliminating pitted flues. This program was started early in 1922, and very gratifying results had been obtained. The boilers carry a very high percentage of alkaline concentration, with little trouble.

The quality of the material used in boiler construction has also been thoroughly investigated. At the present time, most of the railroads have standard specifications for boiler steel. These specifications are strictly adhered to in order to avoid the use of non-homogeneous steel which may set up electrolytic reaction, leading to corrosion.

Protective castings of lead or similar material have also been used with varying degrees of success.

While the entire principles of water softening and the control of corrosion may be explained theoretically in very simple terms, practicable applications are sometimes very difficult. Experimenting with the boiler of a locomotive in operation is entirely different from research conducted in a laboratory. Foam trouble and priming cannot be tolerated. The water-service engineer must be sure of the results. Movement of trains safely is the first consideration. Progress can only be attained with the coöperation of all departments.

The Flow of Air and Steam in Pipes

Equations and Curves in Units Convenient for Engineering Calculations—Check of Friction Factors Appearing in Equations of Unwin and Babcock

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THE expression for the flow of gases and vapors in pipes, where the pressure drop is less than 10 per cent of the final absolute pressure, may be written

$$H = \frac{4\,f\,L\,u_a^2}{2\,g\,d} \qquad [1]$$

where H = the loss in head
f = friction factor
u_a = the average linear velocity of the fluid
d = the diameter of the pipe
L = the length of the pipe
the units being in the foot-second system. Another form of Equation [1] is as follows:

$$P_1 - P_2 = \frac{f\,L\,w_a u_a^2}{6\,g\,D} \qquad [2]$$

where w_a = fluid density, lb. per cu. ft.
$P_1 - P_2$ = the pressure drop in lb. per sq. in.
D = the inside diameter in inches
f = the same numerical value as in Equation [1]
In order that this equation may be used for engineering calculations, it is necessary that the numerical values of f be known for the various conditions which may be met in practice. Thus the correlation of data on the flow of fluids in pipes resolves itself into the problem of expressing f in terms of the variables which may affect it.

As early as 1880 this equation was applied to the flow of compressed air in pipes by Unwin, who found that the value of f decreased as the size of the pipe increased. He expressed the relation between f and D in the form

$$f = 0.0028\left(1 + \frac{3.6}{D}\right) \qquad [3]$$

and solving for the rate of air flow, obtained the form given by Kent[1]

$$Q = 86\sqrt{\frac{(P_1 - P_2)D^5}{w\,L\left(1 + \frac{3.6}{D}\right)}} \qquad [4]$$

where Q = cu. ft. per min. of air at initial pressure
P_1 = initial pressure in lb. per sq. in.
P_2 = final pressure in lb. per sq. in.
D = inside diameter of pipe, in.
w = air density, lb. per cu. ft.
L = pipe length, ft.

This equation is given by the standard engineering handbooks, and is probably used more than any other equation for the flow of air in pipes.

Wm. Cox[2] arrived at a similar result, apparently independently, in 1896. However, instead of employing an equation for f in terms of diameter, he tabulated values of f corresponding to various pipe diameters. In the same year F. A. Halsey[3] applied Cox's formula to data obtained on the flow of compressed air in the air mains of the Mt. Cenis tunnel. He found the data to substantiate to a fair degree Cox's values of the coefficient f, but remarked that the values of f obtained from the data seemed to vary more with air velocity than with pipe diameter. During the fifteen years following, quite a number of books were written on compressed air, most of which quoted the equations of either Cox or Unwin; or a formula similar to that of Cox, derived by F. Richards.

In 1908 Fritzsche[4] carried out very careful experiments on the flow of air at pressures from 0.2 to 11 atmospheres, in sheet-zinc pipes. From his results he concludes f to be a function not only of D, but also of u and w, the air velocity and density. He assumed the functions to be exponential and stated f to be inversely proportional to the 0.269 power of the pipe diameter, and inversely to the 0.148 power of both u and w.

In 1914 an excellent experimental study of the problem was published by Stanton and Pannell,[5] of the National Physical Laboratory, in London. Experiments were made on the flow of both air and water under various conditions in short brass tubes. By dimensional analysis of the variables concerned, it had previously

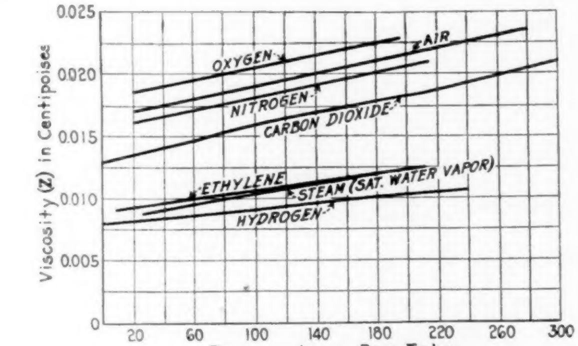

Fig. 1 Temperature-Viscosity Curves for Gases and Vapors
(Data from Landolt, Bornstein Tabellen.)

been shown that the friction factor f should be a function of the dimensionless group DuS/z, where D is the pipe diameter, u the linear fluid velocity, S the specific gravity of the fluid, and z the viscosity of the fluid at the temperature in question, expressed in centipoises. Stanton and Pannell showed this to be the case for their experimental data on air and for their data on water; furthermore they showed f to be the same function of DuS/z for both air and water. Fig. 1 shows curves of the viscosity of gases, rising with increase in temperature.

A number of formulas have been proposed for the friction factor for steam flowing in pipes.[6] However, the one in common use is that of Babcock:

$$f = 0.0027\left(1 + \frac{3.6}{D}\right) \qquad [5]$$

This is seen to be practically identical with that of Unwin for air, the only difference being the change of the constant from 0.0028 to 0.0027.

In 1922 Wilson, McAdams, and Seltzer[7] published data for oils, and by this method correlated a large amount of data for various fluids, summarizing their results in a plot of f against DuS/z. This plot shows two lines, one to be used for pipes of steel or cast iron, and the second for copper or brass pipes. Since this plot has not only a sound theoretical basis, but summarizes a very large amount of experimental data, it has been accepted by many as one of the best bases for calculations regarding the flow of fluids in pipes.

Recently, however, a question was raised as to its applicability to the flow of air or steam under vacuum. Investigation showed that so far as the flow of air was concerned, the above-mentioned plot was based almost entirely on the experiments of Stanton and Pannell with air flowing at atmospheric pressure in brass tubes. The authors therefore undertook to collect the available reliable data for air and steam from the literature and to compare the values of the friction factor so found with the curves on the published plot.

Friction factors were calculated from the results of Fritzsche,[4]

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[1] Numbers refer to bibliography at the end of the paper.

Hussey and Wattles,[8] and Stockalper,[9] for air; of Eberle,[10] Carpenter and Sickles,[11] for steam; of Lander,[12] for both steam and water. These values of f have been plotted on Fig. 2.

Results with Air in Pipes of Steel, Wrought-Iron, Cast Iron, and Sheet Zinc

Hussey and Wattles made experiments on compressed air flowing through several lengths of straight iron pipe, connected in series, with various arrangements of bends and elbows between the sections.

Forty tests were made at absolute pressures between 5.6 and 6.7 atmospheres, with linear velocities ranging from 17.7 to 54.0 ft. per sec. These points are shown in Fig. 2 by the circles at abscissas of 9.5 to 26.

A second set of forty tests were made at absolute pressures ranging from 4.7 to 11.4 atmospheres, while maintaining a constant mass velocity of 19 lb. of air per sec. per sq. ft. of cross-section. The value of DuS/z was constant and the average of the forty values of f are represented by a single point on Fig. 2. Referring to Equation [2], it is seen that the only variables for this second series were $P_1 - P_2$ and w, and that the pressure drop should be directly proportional to the density. If the friction factor is actually constant for these conditions, a plot on logarithmic paper of pressure drop as ordinates versus absolute pressure as abscissas should give straight line having a slope of minus one. These values have been so plotted in Fig. 3, each line representing the data for one of the four different lengths of straight pipe. The slopes are respectively; —0.98, —0.95, —0.97, and —0.95, indicating that f, at a definite value of DuS/z, is not changed appreciably as the absolute pressure is varied.

At a given absolute pressure, say 100 lb. per sq. in., the pressure drop should be proportional to the length, or the drop per unit length should be constant. As shown tabulated on Fig. 3, at 100 lb. the drop per foot varies from 0.0166 to 0.0185 lb. per sq. in., giving an average of 0.0177. This average value corresponds to $f = 0.00514$, at $DuS/z = 17.8$.

Fritzsche made very careful experiments on the flow of air in pipes of sheet zinc, about 50 feet long, and his data are recommended by Marks[15] as the most reliable of any available. The range of variables covered were as follows:

Absolute pressure, atmos.	0.2 to 11
Air velocity, ft. per sec.	8.2 to 121
Air temperature, deg. cent.	14 to 116
Inside diameters, in.	1.016 and 1.53

Symbol		Fluid	Average Pressure Atmosph's	Metal	Diameter, Inches
○	FRITZSCHE	AIR	0.2—11.6	SHEET ZINC	1.531—1.016
●	HUSSEY AND WATTLES	AIR	5.6—6.7	WROUGHT IRON	1.063
⊠	" " "	"	3.6—10.6	" "	"
	AVERAGE OF FORTY POINTS AT CONSTANT MASS VELOCITY				
□	STOCKALPER	AIR	3.6—5.3	WROUGHT IRON	5.91
▲	"	"	3.6—5.3	CAST IRON	7.87
X	LANDER	STEAM	1.0	IRON	0.42—1.29
+	EBERLE	STEAM	2.9—10.1	IRON	2.75
△	CARPENTER AND SICKLES	STEAM	6.8	IRON	2.0
■	LANDER	WATER	1.0	IRON	0.42—1.29

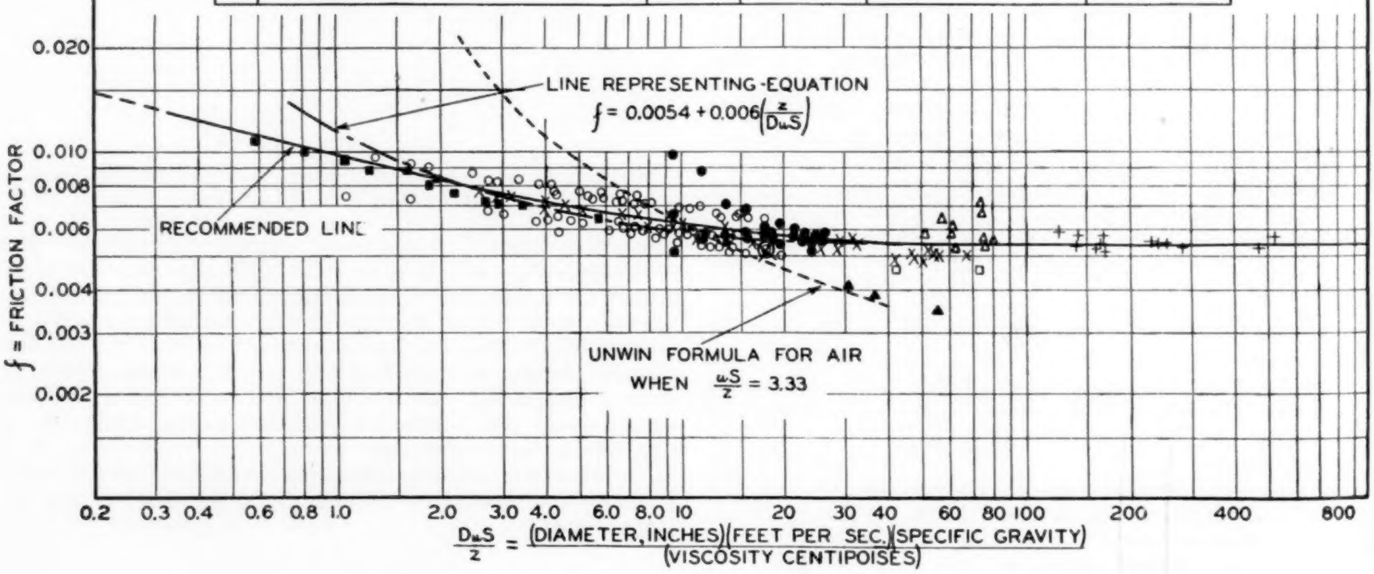

Fig. 2 Plot of Experimental Data

The values of f calculated from these data are plotted on Fig. 2, as shown at values of DuS/z between 1.05 to 20. A study of the data for each pipe showed that u and w had equal effect in determining the numerical value of f. For example, a given value of DuS/z was obtained at several widely differing pressures, but f was found to be constant regardless of the pressure used.

For any value of DuS/z used by Fritzsche, f for the smaller pipe was generally 15 to 25 per cent greater than for the larger pipe, but in some cases the reverse was true. It is believed that for a given DuS/z, there is a tendency for f for small pipes to be somewhat greater than for large pipes, but uncertainties as to the exact actual inside diameter and condition of the surface make it difficult to determine the proper correction.[16] It is therefore recommended that friction calculations be based on the mean line drawn through Fritzsche's points for both small pipes. For if these values are somewhat high for large pipes, one would merely be introducing a factor of safety. As regards the calculation of the rate of flow from friction drop, as will be shown later, the flow varies only as a root function of f, and hence inaccuracies in f become less important.

The experiments of Stockalper, which were made during the con-

struction of the St. Gothard tunnel, are frequently quoted. For the sake of completeness, a few of these points were included, based on air at pressures from 3.6 to 5.3 atmospheres flowing through 1690 ft. of wrought-iron pipe having an inside diameter of 5.91 in., and in cast-iron pipe having an inside diameter of 7.87 in. These values are plotted in Fig. 2 at values of DuS/z from 30 to 74.

AIR IN BRASS PIPES

Fig. 4 is a plot of the results of Nusselt,[13] and Stanton and Pannell[5] for air flowing in brass pipes. The solid line shown is that given by Wilson, McAdams, and Seltzer for copper and brass pipes. The experimental points of Stanton and Pannell for both air at atmospheric pressure, and for water, fall very nearly on a single curve, and hence their results for air at atmospheric pressure in brass tubes are represented by the dotted line extending from DuS/z of 0.7 to 20. In spite of the fact that the data of Stanton and Pannell cover a 28-fold range of pipe diameters, for a given DuS/z, f was independent of the diameter used.

Nusselt's determinations of the friction for air flowing in a brass pipe are seen to check excellently those of Stanton and Pannell. It should be noted that Nusselt's data also cover a wide range of values of DuS/z.

STEAM IN IRON PIPES

Eberle determined the friction loss for both saturated and superheated steam flowing in an iron pipe having an inside diameter of 2.75 in., and found that over a range of velocities from 22.8 to 241 ft. per sec., the value of f varied only from 0.00587 to 0.00527. These data are shown in Fig. 2 at values of DuS/z of 125 to 520.

Fig. 2 also shows the results of Carpenter and Sickles on the flow of steam in a 2-in. iron pipe. The ten points fall at values of DuS/z

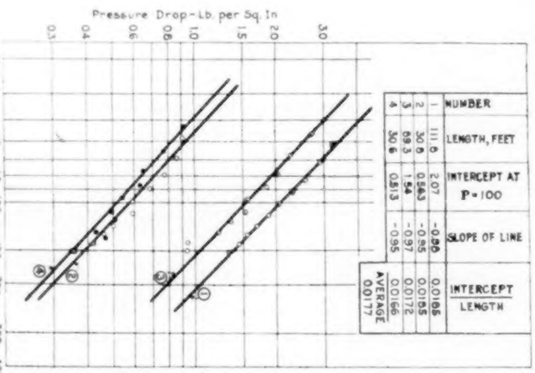

FIG. 3 HUSSEY AND WATTLES, M.I.T. MECH. ENG. THESIS 1908
(Runs of constant velocity—0.1176 lb. per sec.)

of 50 to 80, the results running somewhat higher than those of Eberle.

Lander carried out experiments on the flow of both air and steam in three different iron pipes, ranging in diameter from 0.421 to 1.30 in., and found that the friction factor was the same function of DuS/z for both fluids. This is seen in Fig. 2 where Lander's points for both steam and water fall along a single line from DuS/z of 0.58 to 68.

Fig. 2 shows considerable variations in the results of the various experimenters; no doubt partly due to the varying conditions of roughness to be found in different iron and steel pipes. However, the points in general fall slightly higher than the line previously published for iron and steel pipe, and as the deviation is in an unsafe direction, it has seemed advisable to draw a new line. This line is shown drawn through the points on Fig. 2, and is recommended for use with iron and steel pipe. In case one did not wish to employ a chart, or a table of values of f versus DuS/z, the empirical equation

$$f = 0.0054 + 0.006\ (z/DuS) \qquad [6]$$

represents this recommended line quite well except for values of DuS/z less than 1.5. This equation is represented by the dashed line shown on the plot.

COMPARISON OF UNWIN AND BABCOCK FORMULAS WITH RECOMMENDED LINE

The data of Nusselt may be cited as an example to show the unreliability of the Unwin formula in which f is a function of the pipe diameter alone. According to such a form of equation, the friction factor f should be constant for all of Nusselt's experiments, since the tests were all made with the same pipe; however, reference to Fig. 4 shows that Nusselt obtained values of f varying twofold, depending on the air velocity and pressure.

In order to locate the Unwin equation on Fig. 2, consider air at atmospheric pressure and room temperature flowing at an average velocity of 50 ft. per sec. Then $S = 0.075/62.3$ or 0.0012, $u = 50$, and from Fig. 1, $z = 0.018$. Hence $DuS/z = D\ (50)\ (0.0012)/0.018 = 3.33D$. For a diameter of one inch, DuS/z equals 3.33, and f from Fig. 2 is 0.0075, whereas the Unwin formula, Eq. 3, gives $f = 0.0129$, which is 72 per cent higher than the recommended value. For a 12-in. pipe, the Unwin equation gives a value of f 35 per cent lower than the recommended line of Fig. 2. The curved dotted line on Fig. 2 represents Unwin's relation for free air at 50 ft. per sec., and as shown above, gives high values of the friction factor for small pipes, and low values for large pipes. For air under pres-

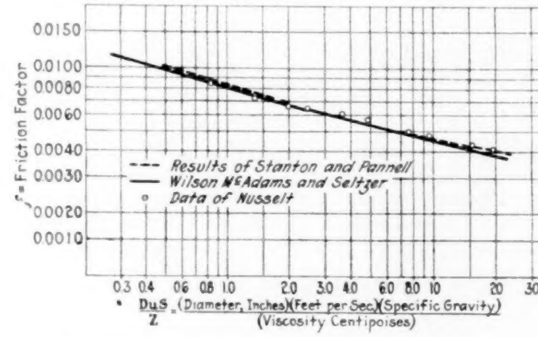

FIG. 4 FLOW OF AIR IN COPPER AND BRASS PIPES

sure the curve would be moved to the right on the plot, and the values of f indicated by the Unwin equation would be even higher, as compared to the recommended curve, than before. Thus the Unwin form is particularly unreliable for air under pressure in medium or small pipes, or for air under vacuum in large pipes.

The Babcock formula for the friction factor for steam is similarly limited, since it is of the same form as that of Unwin for air. Over the general range of variations in the value of DuS/z for the flow of steam, Fig. 2 shows that the friction factor lies between 0.005 and 0.006. These values of f are given by the Babcock formula for pipes from 3 in. to $4^1/_4$ in. in diameter, in which range the Babcock formula holds well. However, it is seen to be unduly safe for pipes considerably smaller than 3 in., and is probably unsafe for large pipes, although no data have been found for steam in large pipes.

METHODS OF CALCULATION

For calculations involving the flow of air in pipes, the original equation for fluid flow is generally modified in several ways. The density of the air in pounds per cubic foot may be expressed as

$$w = 2.70\ P/T \qquad [7]$$

where w = the density as lb. per cu. ft.
P = absolute pressure in lb. per sq. in.
T = the absolute temperature (= 460 + deg. fahr.)

If the pipe diameter be d feet or D inches, the pipe length L feet, and the linear air velocity u ft. per sec., then Equation [1] becomes:

$$P_1 - P_2 = \frac{f\ L\ w_a\ u_a^2}{6\ g\ D} \qquad [2]$$

The subscripts 1 and 2 refer to conditions at the two ends of the pipe, and the subscript a refers to the average values over the length of the pipe. The volume of air Q_1, as cubic feet per minute, flowing at the pressure P_1 may be calculated from the equation:

$$Q_1 = \frac{3.14\ D^2\ 60\ u_a\ w_a}{4\ (144)\ w_1} \qquad [8]$$

hence, from Equations [2], [7], and [8],

$$P_1 - P_2 = \frac{0.13\, f\, L\, Q^2\, P^2}{P_a\, D^5\, T} \quad [9]$$

and

$$Q_1 = 2.77 \sqrt{\frac{D^5\,(P_1 - P_2)\;T\;P_a}{f\;L\;P_1^2}} \quad [10]$$

The last two equations are most serviceable for the solution of ordinary problems, providing the proper value of f be known. Since QP is constant at all points along the pipe, the values to be substituted in Equation [9] may correspond to any pipe section; but values of Q and P must be taken for the same section.

From the relations used above it may be shown that

$$\frac{DuS}{z} = \frac{0.132\, Q\, P}{z\, D\, T} \quad [11]$$

Hence it is possible to replot the curves of Figs. 2 and 4 against QP/DT for different values of z, making it unnecessary to refer to Figs. 1, 2, and 4. Fig. 5 shows such a friction-factor plot for air, f

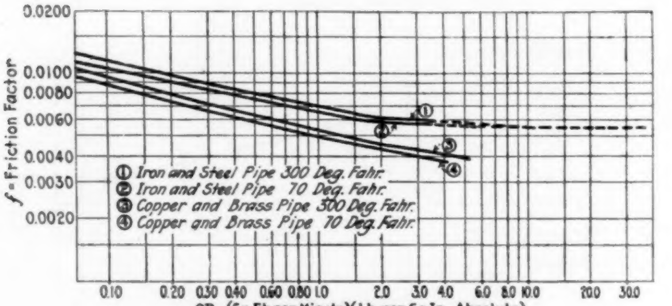

FIG. 5 FRICTION-FACTOR PLOT FOR AIR

being plotted against QP/DT, lines at two temperatures being given for both iron and brass pipes. Values of f at other temperatures may be obtained by interpolation.

The general equation may be similarly modified for the flow of steam in pipes. If G be the flow of steam in pounds per minute, then from Equation [2]

$$P_1 - P_2 = 0.0484\, \frac{f\, L\, G^2}{D^5\, w_a} \quad [12]$$

$$\text{and } G = 4.54 \sqrt{\frac{D^5\, w_a\,(P_1 - P_2)}{f\, L}} \quad [13]$$

DuS/z may be expressed as $0.0490\, G/Dz$, so that the friction factor could be plotted against G/Dz rather than DuS/z. For any temperature the value of z is a constant, so that it is possible to plot a number of curves of f against G/D, each for a different temperature. However, the friction-factor plot is a very flat curve over the range ordinarily used for steam, and moreover the viscosity of steam changes roughly only 50 per cent over the range from 200 to 500 deg. fahr. As a result, changes in temperature only affect the abscissas and do not materially change the numerical value of the friction factor read from the curve. Therefore, for practical purposes, it is sufficient to use a single line of f against G/D, as shown drawn in Fig. 6 for steam.

For turbulent motion, Wilson, McAdams, and Seltzer[7] give the resistance of standard 90-deg. elbows as equivalent to a frictional length of 30 diameters of straight pipe. To the length of straight pipe in the line should be added a length $30 \times D/12 = 2.5\, D$ feet for each elbow, giving the total length L to be used in all the equations involving L.

In résumé, Equations [9] and [10] are recommended for calculations involving the flow of air, and Equations [12] and [13] for the flow of steam. The friction factors are obtained from Fig. 5 for air, and from Fig. 6 for steam.

These equations apply with sufficient accuracy where the pressure drop does not exceed 10 per cent of the initial absolute pressure. Where the friction is greater than this, one should employ the methods given in reference 14. These values of f apply to relatively clean pipes. For badly corroded or tuberculated pipes, for safety f should be taken as 0.010, for values of DuS/z greater than 1.0.

The units used in these formulas are as follows:

P_1 = initial pressure, lb. per sq. in. abs.
P_2 = final pressure, lb. per sq. in., abs.
P_a = average pressure, lb. per sq. in. abs.
Q_1 = cu. ft. of air per min., at pressure P_1
Q = cu. ft. of air per min., at pressure P
D = inside diameter of pipe, in.
L = equivalent frictional length of pipe, ft., = length of straight pipe in feet, plus 2.5 D times the number of elbows
T = air temperature, deg. fahr. absolute (= 460 + deg. fahr.)
f = friction factor, see Figs. 5 and 6
G = lb. steam per min.
w_a = lb. per cu. ft. of fluid flowing at average pressure and temperature.

The calculation of the pressure drop, knowing the rate of flow, is straightforward and not difficult, but the reverse calculation involves a simple trial and error problem. As an example of this second case, the calculation is given below of the air flow at 70 deg. fahr. through a standard 2-in. wrought-iron pipe between two points at 70 and 66 lb. per sq. in. absolute, the pipe being made up of 60 ft. of straight pipe and four standard elbows. The actual inside diameter of this pipe is 2.07 in.

$$Q_1 = 2.77 \sqrt{\frac{2.07^5 \times 4 \times 530 \times 68}{f\left\{60 + \left(\dfrac{4 \times 30 \times 2.07}{12}\right)\right\} \times 70 \times 70}} = \sqrt{\frac{10.63}{f}}$$

$$\text{and } \frac{QP}{DT} = \frac{Q_1 \times 70}{2.07 \times 530} = 0.066\, Q_1$$

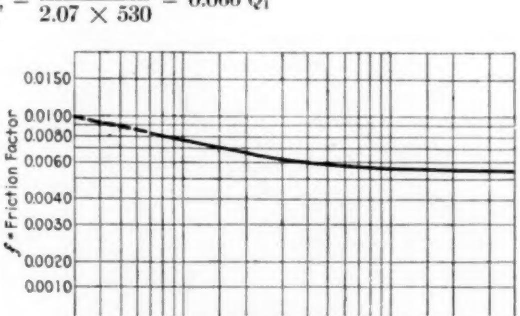

FIG. 6 FRICTION-FACTOR PLOT FOR STEAM IN IRON AND STEEL PIPES

First a value of f must be assumed; for example, first suppose f = 0.006. Hence $Q_1 = \sqrt{10.63/0.006} = 133.1$, and $\dfrac{QP}{DT} = \dfrac{133.1 \times 70}{2.07 \times 530}$ = 8.49; and from Fig. 5, f = 0.0056. Using this value of f as a second assumption, Q_1 = 137.9; QP/DT = 8.80, and from Fig. 5, f = 0.0056, checking the assumed value of 0.0056. Q_1 is thus 137.9 cu. ft. per min. at 70 deg. fahr., and 70 lb. per sq. in. absolute.

Such a trial and error calculation, characteristic of the determination of the rate of flow from the observed friction drop, may be avoided by the use of alignment charts constructed for the purpose.

SUMMARY

Friction data for the flow of air and steam in pipes have been calculated in a common set of units. Aside from the effect of nature of the surface of the pipe, the numerical value of the friction factor f is determined by inside diameter D, fluid velocity u, specific gravity s, and viscosity z. Furthermore, f is a function of the ratio DuS/z. This method of grouping the variables, which is dimensionally sound, correlates the data better than any other method now in use. The nature of the function connecting f and DuS/z was determined by plotting. Fortunately data were available covering a very wide range of values of DuS/z. For any given

value of DuS/z, the value of f for pipes of steel, wrought iron, cast iron, and sheet zinc is somewhat higher than for brass or copper.

Equations and curves are given in units convenient for engineering calculations, with f as a function of rate of flow, diameter, pressure, and temperature.

In calculating friction factors, engineers apparently employ the equations of Unwin for air and Babcock for steam. Both of these equations were found to be unreliable, except for special conditions. This is due to the fact that f actually varies with three factors other than diameter, while the Unwin and Babcock equations for f allow for diameter only. In general, the Babcock equation for f is less in error for steam than the Unwin for air, because f for steam depends less on all four factors than does f for air.

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Progress of Standardization in Industry

IN A PAPER on The Work of the American Engineering Standards Committee, presented before the Annual Convention of the American Institute of Electrical Engineers at White Sulphur Springs, W. Va., on June 23, 1926, Mr. C. E. Skinner mentioned some of the most important achievements of the Committee to date and discussed problems which must be faced before standardization can produce maximum results in industry. He also mentioned the recent attempts to effect international standardization in certain lines of industry.

The fact that there are in the United States more than five thousand organizations, some hundreds of which are endeavoring to formulate standards, at once shows the necessity for an increased program of coöperation by some comprehensive organization such as the American Engineering Standards Committee. The collection of something over twenty-five thousand specifications covering six thousand commodities by the Department of Commerce into the Directory of Specifications further indicates the necessity for the simplification of our specifications and standardization work. When a single class of material is purchased in the United States by different groups under from twenty to perhaps a hundred different specifications, it becomes at once evident that quantity production to suit all the needs of the industry for such commodities is impossible. A proper program of standardization will enable us to continue our high wages and allow us to compete successfully in the markets of the world and provide high grade commodities at reasonable prices for the use of the masses.

A much more comprehensive and coördinated endeavor should be made to bring about truly national standardization, he felt. He did not believe that more effort or the expenditure of more time and more money were needed, but that a better coördination of effort and a more efficient expenditure of our time and money in our standardization work were essential. Mr. Skinner quoted the following from the A.E.S.C. Year Book, 1925, which clearly indicates the confusion that may be expected in the absence of coördination.

"The number of important organizations found in practice to be concerned in any particular project is surprisingly large. It is on this account that the standards of associations have not as a whole come into more extensive use than they have, and that so few of them, relatively, have become real national standards. In most cases such standards have been developed wholly within a single association. As a result, other organizations and their members, having had no direct knowledge of, or sense of participation, direct or indirect, in the initiation or in the development of a standard, are not apt to be predisposed to use it, however good it may be. Such tendencies of men are deeply grounded in human nature and, quite apart from the intrinsic merits of the standards themselves, are of great significance and importance in the standardization movement."

Those engaged in standardization work very often overlook the fact that as a rule standards which have to do with commercial matters are of necessity compromises. It is much better to put into operation reasonable standards, although they may not be perfect, than to strive indefinitely for perfection, in the meanwhile having no standard. The use of the standard will soon show its weaknesses and revisions will sooner or later be found desirable. The machinery of the American Engineering Standards Committee has been designed to care for revisions through its scheme of sponsorships and sectional committees.

The international program of the Committee has, in the past, been mainly directed to the exchange of information with the engineering standardizing bodies of other countries, and the disseminations of this information to those interested in our own country with some attention to specific projects. Recently, however, a meeting of the chairmen and secretaries of the national standardizing bodies of the world was held in New York, N. Y., at which time, through the initiative of our European friends, a move was made towards the organization of an International Standards Association. At this time a tentative constitution for such an association was adopted and a committee, consisting of a member from each of seven nations, was authorized, this committee, being empowered to consider suggestions and criticisms in regard to the proposed constitution, to confer with the International Electrotechnical Commission with a view of harmonizing the work of the two groups and to call a plenary meeting for final consideration and ratification of the Association. It is too early to predict just what will be the outcome of this movement, but it was perfectly evident to those present through the series of meetings held in New York that such an association could be made of very great value to all of the industrial nations.

Industry needs publicity to the effect that standardized goods are both better and cheaper than specialties. The standardization movement needs the backing of industry generally to a point where standards agreed upon are adopted and used. Standardization groups in overlapping fields need to have earlier contact with each other so as to obviate much overlapping and wasted endeavor. American industry needs some authoritative body through which this very desirable coöperation can be effected.

Mr. Skinner believed that the fundamental principles on which the American Engineering Standards Committee is founded provide the best means yet suggested for bringing about this very much desired result. In order to do so, however, the Committee needs increased moral and financial support and the increase of its membership to include all those groups which are engaged in the national program of standardization.

It would be a very great advantage both to the Committee and to its constituent organizations if a much closer working relationship could be established; and as a means to this end it is suggested that organizations having a major program of standardization to be cleared finally through the A.E.S.C. as an American Standard, should locate liaison members in the office of the Committee. Such members would keep their organizations in the closest possible touch with all matters coming before the American Engineering Standards Committee of interest to their respective groups; and they would be of very great benefit to the Committee in keeping the headquarters in touch with the activities of the member bodies.

The Termination of Charcoal Tests

By F. L. KALLAM,[1] LOS ANGELES, CAL.

IN TESTING natural gas for gasoline content a metered amount of the gas is allowed to pass through a tube containing activated charcoal. The gasoline adsorbed by the charcoal is then recovered by means of distillation with glycerine and the volume of the condensate noted. With this information at hand the gallons of gasoline per thousand cubic feet of gas is readily calculable.

Fig. 1 gives the results of temperature measurements obtained when passing various amounts of a rich gas through a tube containing 250 cc. of 8- to 14-mesh charcoal. The four characteristic temperature rises and falls, typical of all wet gases, are clearly illustrated. In some cases even a fifth rise and fall has been observed, and it is believed that with suitable apparatus, the fifth rise might more readily be detected, and perhaps a sixth and seventh.

Charcoal possesses the inherit property of adsorbing the gasoline constituents of a gas most readily, showing marked preference for heptane, hexane, and pentane in the order named. But when gas first comes in contact with charcoal, there is not enough heptane, hexane, and pentane present to satisfy the capillary capacity of the charcoal, with the result that butane, propane, ethane, and methane are also adsorbed. The charcoal continues to adsorb until the condensed hydrocarbons equal in volume the volume of the capillaries, and up to this point no hydrocarbons escape adsorption. As more and more gas enters the charcoal beyond this point, a greater amount of heavier hydrocarbons are presented for adsorption; but in order for the charcoal to hold these, it is necessary to provide the capillary volume. This it can do only by releasing some already adsorbed constituents, and these will be the ones for which it has the least affinity.

This is the condition existing in the charcoal at the top of the first temperature rise (Fig. 1), or first saturation point. The rise in temperature up to this point can thus be said to be due to the heat of adsorption of the various hydrocarbons, and in particular to methane, because of the latter's greater predominance in the gas.

It is at this first saturation point that the maximum gasoline content will be found, bearing in mind the relation between gasoline and gas volumes. However, due to the composition of this gasoline as previously explained, exorbitant condenser pressures would have to be applied, accompanied by low temperatures, in order to secure complete condensation. Such gasoline, even if produced, would at present have no commercial value because of its volatility.

It now remains to be seen what hydrocarbons will be released after the first point of saturation is reached in order that the charcoal may avail itself of the more desirable gasoline constituents. Obviously, this will be methane, for which the charcoal has the least attraction. This expulsion of methane is clearly shown in Fig. 1 by the fall in temperature after the first saturation point, showing that the heat of adsorption during this period is utilized to revaporize the methane. At the second saturation point we find the condition that for the charcoal to adsorb further, it will be necessary to replace the lightest hydrocarbon already adsorbed, ethane, in order to provide capillary volume.

The gasoline now available in the charcoal for extraction, by virtue of the absence of all methane, is slightly more stable.

Passing the second saturation point, we find ethane being replaced by heavier hydrocarbons, of which propane is in the greatest volume. The gasoline adsorbed and held by the charcoal at the third saturation point is still very "wild," due to the propane present.

Passing the third saturation point, all methane, ethane, and propane coming in with the new gas now go untouched through the charcoal, while all the butane, pentane, hexane, etc., are adsorbed. Here again there is a deficiency in the volume of the heaviest hydrocarbons, so that a very large amount of butane is adsorbed in order to satisfy the charcoal as regards volume of hydrocarbons held. With this volume the fourth saturation point has been reached as shown by the fourth temperature rise in Fig. 1.

Continuing past the fourth saturation point, this process of replacement continues until a sufficient volume of the heaviest hydrocarbon present in the gas to fill the capillaries of the charcoal has been passed through the latter. From this point on, no hydrocarbons will be adsorbed; all passing unadsorbed through the charcoal. This condition is the total-saturation point, and the gasoline content based on this volume will perhaps be only 5 per cent of that shown at the first saturation point.

From the analyses of many samples of natural gasoline, it has been found that very few, if any, hydrocarbons lighter than propane are present. Propane is found to the extent of 1 to 5 per cent, and while it has a low boiling point, it cannot be freed from the gasoline without carrying away with it other heavier and more valuable gasoline constituents. Hence propane is a serious and objectionable constituent of gasoline, being of such nature as to be commercially detrimental. By eliminating it, a greater amount

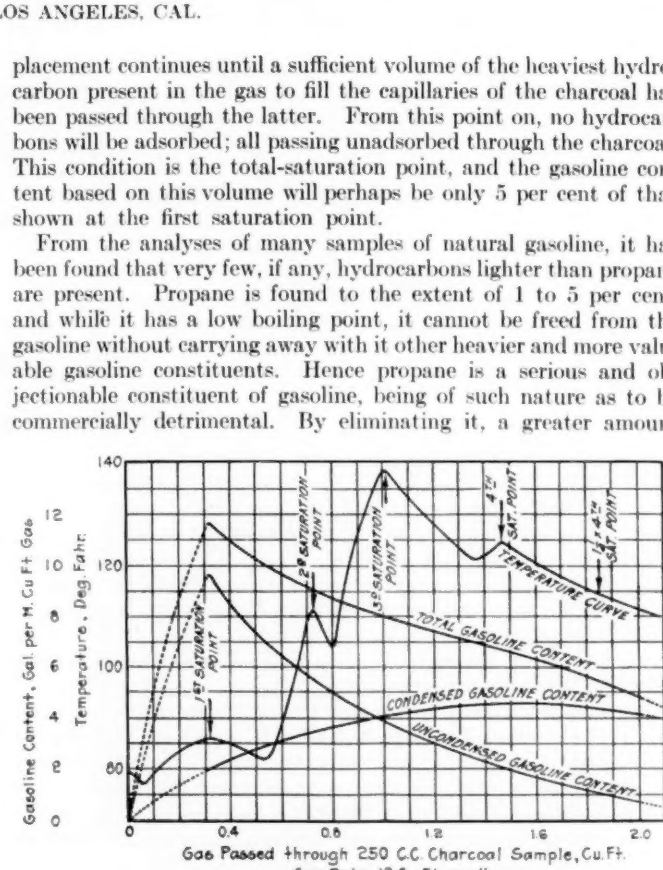

Fig. 1 Relation Between Saturation Points and Gasoline Content

of butane may advantageously be contained in gasoline without abnormal losses in handling.

By stopping at the fourth saturation point we are assured of condensing, within the pores of the charcoal, a volume of desired gasoline which will give a maximum gasoline content for the gas. To obtain this it is necessary to recover this adsorbed gasoline by distilling and condensing. As a result of countless tests, however, using 250 cc. of 8- to 14-mesh charcoal and distilling and condensing equipment having the same dimensional ratio to each other in every instance, it has been found that the maximum gasoline content is not always obtained at the fourth saturation point.

One remedy for such a condition is to run the test past the fourth saturation point, or in other words, displace, at least to some extent, the butane with pentane. It has been found, however, that the maximum test always lies within a narrow limit, that is between the fourth saturation point and a point which corresponds to 1.25 times the volume at the fourth temperature rise. This latter point may be defined as the saturation of the charcoal secured by passing 1.25 times the volume of gas required to reach the fourth saturation point through the charcoal. This rule holds for wet gases ranging from $^1/_2$ gal. upward. For gases with $^1/_2$ to $2^1/_2$ gal. contents the 1.25-point has been found very satisfactory for the maximum yield, but for the richer contents, the fourth saturation point will give slightly higher results.

By resorting to pressure condensation, it is possible to recover 95 to 97 per cent of the gasoline (by weight) adsorbed by the charcoal at the fourth saturation point. This makes it convenient for field testing, as the adsorption can be stopped in every case at the fourth saturation point. A pressure of 45 lb. per sq. in. absolute and a temperature of 60 deg. fahr. will assure of this degree of condensation in practically all cases. Even after weathering, condensate obtained by this method to atmospheric conditions, with a loss from 10 to 15 per cent, a higher yield will be obtained for the same gas than will be by atmospheric condensation.

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Waste-Heat Boilers in Steel Mills

By F. H. Willcox[1] and J. C. Hayes, Jr.,[2] Chicago, Ill.

Interest has been recently revived in the utilization of low-temperature waste gases in boiler installations. For waste-heat boilers rapid water circulation is not a prime requisite, but there must be maximum heat recovery by conduction and convection, and therefore the most intimate contact of gases and water-heating surface. Close tube spacing in a water-tube boiler and gas velocities higher than those of natural draft in the fire-tube boiler are essential. Draft losses become important. Water-tube and fire-tube boilers are compared in the paper on the basis of heat transfer and draft loss. Various types of gas flow are discussed. Rules are laid down for the permissible loss in energy to provide forced draft in waste-heat installations. A number of typical installations are discussed. The economic value of the recovery of waste heat in open-hearth steel furnaces, in cement-kilns, and in other applications is dealt with.

The marked success of some recent installations of fire-tube waste-heat boilers has revived the interest of many engineers and plant operators in the recovery of heat from comparatively low-temperature waste gases. Experience continues to indicate that many of the accepted rules of boiler design for direct firing do not apply in waste-heat practice.

Differences in Principle in Direct-Fired and Waste-Heat Boilers

It is generally conceded that close to 70 per cent of the total heat absorbed in a direct-fired standard water-tube boiler occurs in the first rows of tubes exposed to the radiant heat of the furnace, which is ordinarily not more than 15 per cent of the total water-heating surface. It is for this reason that one feature common to all successful types of direct-fired boilers is that of rapid and positive water circulation in the tubes thus exposed.

In a waste-heat boiler utilizing waste heat at 1200 deg. fahr., the radiant heat available is less than one-tenth of that available in a direct-fired boiler where furnace temperatures of 2700 deg. or over prevail. Therefore rapid water circulation is not a prime requisite in the waste-heat boiler, but it is highly important that the waste-heat boiler accomplish the maximum heat recovery by conduction and convection. Consequently it must be arranged to produce the most intimate possible contact of gases and water-heating surface.

It is essential that the waste gases pass as close to the heating surface as possible, and there must be a positive scrubbing or tumbling action which can be brought about only by close tube spacing in the case of a water-tube boiler, or the use of small-diameter tubes in a fire-tube boiler. In either case it is necessary to pass the gas at a velocity higher than is possible in most cases by natural draft alone. The velocities employed are high enough to break up the definite stream lines along which the gas tends to flow, and to prevent the formation of an insulating film of cool gas close to the heating surface which would otherwise allow a hot center or core of gas to pass on without giving up its quota of heat. In Fig. 1 the variation of the character of the fire-tube gas flow at different velocities is indicated diagrammatically.

Heat Transfer and Draft Loss

The two most important requisites in proportioning boilers for a given amount and temperature of waste gases are a high rate of heat transfer and a low draft loss. Both depend on mass velocity, which for purposes of comparison is generally taken as the weight of gas in pounds per hour divided by the area of gas passage in square feet; but the draft loss varies as the square of the velocity, so that the boiler arrangement designed for attaining a high heat-transfer rate must be compromised to keep the friction loss within economical limits.

It so happens that whereas the water-tube boiler at a given mass velocity and tube diameter has a higher heat-transfer rate than the fire-tube type, nevertheless the friction loss in the fire-tube boiler is much less.

Because of its low friction loss the mass velocity may be raised in the fire-tube type of waste-heat boiler, and consequently the rate of heat transfer may be so increased as to exceed that obtained in the water-tube type, while keeping the friction loss the same.

Fire-Tube and Water-Tube Boilers Compared

Figures have repeatedly been published comparing fire-tube and water-tube boilers on this basis, assuming always the heating surface on the gas side in both cases to be perfectly clean. The fire-tube boiler shows up to much better advantage in actual practice on account of the ease with which the heating surface may be maintained practically free of dust deposits and the difficulty of maintaining the water-tube boiler in the same condition.

In Fig. 1 the paths of gases in fire-tube and water-tube boilers are contrasted. In direct-fired practice there is a definite advantage in a design that passes the products of combustion across the tubes substantially at right angles to the center line of the tubes as in the vertically baffled, horizontal, straight-tube types, over the design that passes the gases parallel or nearly parallel thereto. This advantage in direct-fired practice is largely discounted in waste-heat practice for the reason that much greater quantities of gas are passed per unit of heat transferred, and a greater draft loss occurs for the same weight of gas passed per square foot of gas-passage area, imposing a correspondingly greater load on the exhaust fan. The net evaporation is substantially the same for either type of water-tube waste-heat boiler. While a number of water-tube boiler types have parallel flow over a large part of the heating surface, the flow at the entrance, cross-over, and exit passages is substantially at right angles to the tube center lines. This latter type is generally baffled for two passes and has the lowest relative draft loss of any of the water-tube types.

It is evident that no practical combination of tube spacing and baffling of water tubes can possibly bring about as close a contact of the gases with the heating surfaces as is possible in a fire-tube boiler for the same draft loss. Obviously, where 2-in. tubes are used, none of the waste gas can be further than 1 in. from the heating surface in passing through the boiler, and consequently the heat transferred by conduction alone has the shortest possible path.

Gas should pass through the boiler with the least possible number of changes in direction of flow, and with the least possible loss due to irregular channels of flow. The ideal gas path, then, is that offered by a continuous single circular passage, such as the inside of a tube, and the smaller the diameter can be made, the closer will the gases adhere to the heating surface and the better will the heat transfer be. This design does not allow any short-circuiting of gases through baffles, or any by passing of heating surface due to dead pockets in the path of travel. There is no path of least resistance; all tubes are of the same diameter, and there is no baffling.

Necessity for Frequent Tube Cleaning

In order to obtain the maximum economy with any type of boiler in waste-heat practice, it is absolutely essential that the heating surface be kept clean in the fullest sense of the word. This is one of the most troublesome operating problems, and while the frequent use of permanent and hand soot blowers is fairly efficient on the outside of tubes, the best results are obtained where a steam or air jet is introduced at the end of a long tube where the steam or air is closely confined in the tube, and the entire length is thoroughly scoured in a few seconds. This is really one most important feature of a single-pass horizontal fire-tube boiler in that it insures the same performance day after day as obtained in test under the best supervision.

Fig. 1 also shows the method adopted for dusting tubes, which is accomplished by opening only two small wickets, one for observing the operations and one for the introduction of the steam

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lance. The entire tube heating surface is cleaned in this way as frequently as desired. In the case of a boiler taking waste gas from an open-hearth furnace, once in twelve hours is frequent enough to prevent a rise of over ten degrees in the final gas temperature.

Types of Boilers

Some rather discouraging results have been obtained in attempts to use cross-tube boilers for the recovery of heat from furnaces wasting gas at 1200 deg. fahr., although these same boilers are giving excellent results in recovering heat from forge furnaces where gases are wasted at temperatures exceeding 1800 deg. fahr. the same boiler were used over a furnace having 2700 deg. flame temperature.

The water-tube boiler has an advantage over the fire-tube boiler in being more accessible for the removal of scale from the heating surfaces, so that the proper treatment of boiler feedwater should be assured in any contemplated installation of fire-tube boilers. Much prejudice against the use of a fire-tube boiler is based on the failure of its type to compare favorably with the water-tube boilers in meeting the demands of high-pressure stationary work. Many of the factors contributing to this feeling do not apply in waste-heat practice, and others have been eliminated or greatly minimized in modern fire-tube practice.

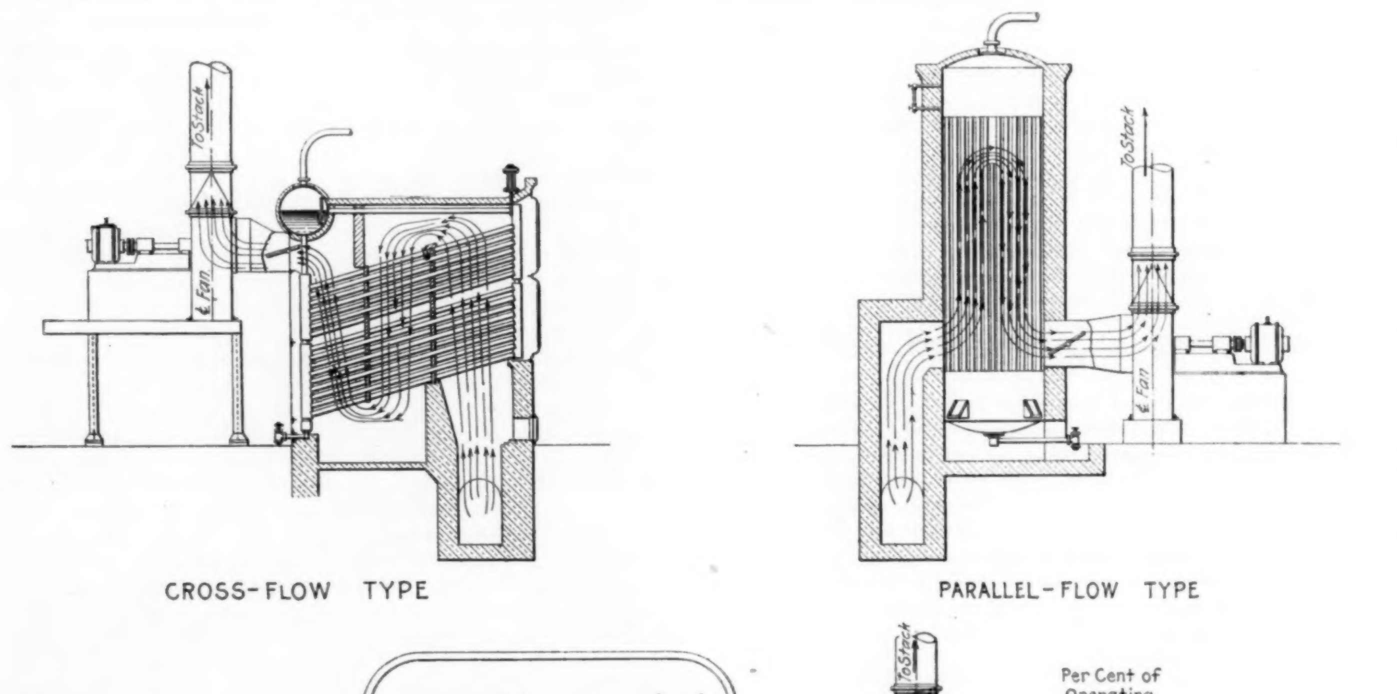

FIG. 1 DIFFERENT ARRANGEMENTS OF FIRE-TUBE AND WATER-TUBE BOILERS, AND CHARACTER OF GAS FLOWS

This is simply further proof of the effect of heat transmission by radiation.

The amount of heat transferred by radiation varies about as the fourth power of the temperature difference between the tubes and the radiating surfaces.

Contrasting a boiler set over a forge heating furnace where the initial temperature of waste gases averages 2000 deg. fahr., and a waste-heat boiler set in the path of waste gases from an open-hearth furnace where the initial temperature is 1200 deg. fahr., the absorption by radiation factor would be as follows:

$$\frac{T_c^4}{T_w} = \frac{(2000 + 460)^4}{2460} : \frac{(1200 + 460)^4}{1660} \text{ or } 4.9:1$$

The comparison of heat absorption by radiation in the two cases is thus 4.9 to 1 in favor of the higher temperature range, and correspondingly less heat absorption is necessary by conduction and convection to make a credible showing in the amount of heat recovered. As stated before, this ratio would be 10 to 1 in case

The waste-heat boiler does not have the high radiant heat to absorb, and it is therefore not necessary to resort to the customary means of passing the gases across the lower half of the shell as in the horizontal-return tubular setting, nor to install fireboxes, water legs, or other extensive stayed flat surfaces.

Advances have been made in the science of treating water for boiler-feed purposes, and a satisfactory treatment can be assured for practically any kind of water.

Experience has shown that tube leakage in a waste-heat boiler of this type is not a serious factor. The flow of gases is seldom over a very wide range in temperature. There is no occasion to open large firing doors, or otherwise let cold air strike the tube sheet, and tubes may be electrically welded to the heads if desired. In practice it has not been necessary to resort to electric welding in the horizontal settings, and some of these boilers have been in operation over three years.

Any loose mud or scale formations fall to the bottom of the drums and are kept away from the heated surfaces.

A much higher content of solids in solution in the boiler water

is permissible on account of the comparatively low and steady rate of evaporation, the greater liberating surface for steam and water separation, and the large amount of contained water per unit evaporated. No brick setting is required to enclose the pressure parts, so there is no cold-air infiltration and very little heat lost by radiation. A fire-tube boiler may be installed in much less space than is necessary for a water-tube boiler of the same heating surface, and less heating surface for the same output is necessary in the fire-tube type. Installation cost is thus generally less for the fire-tube boiler.

Induced Draft in Waste-Heat Boilers

Many existing installations of waste-heat boilers are heavily penalized in net return on account of the excessive use of power necessary to maintain furnace draft and draw the gases through the boilers.

The energy used in the fan drive for drawing the gases through the fire-tube boiler should not exceed five per cent of the boiler output where it is necessary to provide the equivalent of natural draft for furnace operation, and in such cases as puddle furnaces, forge heating furnaces, cement kilns, etc., where regenerators are not used the power for driving fans should not exceed three per cent of the boiler output.

Where regenerators are used, all water cooling of reversing dampers should be dispensed with if possible. In two recent installations, dry dampers set at an angle of 15 deg. from the vertical have been adopted and have proved entirely satisfactory. The straight-away gas passages offer the least possible obstruction of gas flow, and the absence of water cooling allows the waste gases to reach the superheater at the highest possible temperature.

As early as 1910, when the first experiments with water-tube boilers and low-temperature gases were conducted, it developed that much closer tube spacing and more restriction of gas flow by closer baffling were necessary in waste-heat work than in standard boiler practice. This naturally led to higher draft losses and correspondingly higher power consumption of induced-draft fans, even with perfectly clean heating surfaces. The difficulty of properly removing dust, baffle leakage, and air infiltration through brick settings were serious drawbacks in the first efforts to utilize water-tube boilers in this field, but have been to some extent corrected in later installations by the closer grouping of permanent soot blowers, supplemented by hand lances, the use of monolithic baffling, and enclosing the entire brick setting in steel jackets.

Test data obtained on one of two fire-tube units installed at the plant of the National Malleable and Steel Castings Company at Melrose Park, Illinois, in connection with 25-ton open-hearth furnaces, are given in Table 1.

TABLE 1 TEST OF WASTE-HEAT BOILER

(National Malleable & Steel Castings Company, Melrose Park Works, Melrose Park, Ill., June 17, 1925)

Test	No. 1	No. 2	No. 3
Duration of test, hr	7	8.25	8.75
Steam pressure, lb. gage	140.9	140.0	133.8
Temperatures, deg. fahr.:			
Gas before superheater	1348	1338	1331
Gas before fan	485	490	478
Steam after superheater	495	473	484
Feedwater	175	187	184
Drafts, in. of water:			
Before superheater	0.63	0.64	0.64
Before boiler (after superheater)	0.91	0.91	0.91
Before fan (after boiler)	3.20	3.19	3.20
Base of stack (after fan)	0.84	0.87	0.85
Evaporation:			
Total, lb	53,485	65,169	75,095
Average, lb. per hr	7,641	7,899	8,582
Average CO_2 in waste gases (per cent by vol.)	9.06	8.71	8.55
Average oil consumed, gal. per hr	152.7	155.2	160.5
Fan data:			
Speed, r.p.m.	644	651	645
Calculations and results:			
Boiler horsepower developed			
Total	258.0	261.8	286.5
Superheater	16.7	14.6	17.6
Boiler	241.3	247.2	268.9
Temperature of saturated steam, deg. fahr	361	361	357.5
Superheat, deg. fahr	134	112	126.5
Weight of waste gases, lb. per hr	38,500	39,800	43,200
Input to fan motor, brake hp.	18.1	18.9	19.5
Rating of boiler, per cent	102.5	105.0	114.5

In this instance the heat contained in the steam delivered at the outlet of the superheater represents 39.2 per cent of the heat value of the fuel used in the furnace, and the fan used 2.8 per cent of the boiler output, leaving 38 per cent of the furnace fuel recovered in the form of steam. The three tests tabulated are simply three divisions of a continuous twenty-four hour test divided into the three periods for the purpose of comparing the boiler performance over the three open-hearth heats taken out in the twenty-four hours.

At Melrose Park there has been a marked improvement in open-hearth-furnace performance due to the better draft available since installing the waste-heat boiler, the furnace output having increased substantially 20 per cent over the former practice due to improved draft conditions.

The authors' experience has been that the induced draft incident to the use of a waste-heat boiler is not only an advantage in regular furnace operation by reason of having more intensity and being subject to better control than natural draft, but the life of regenerators is much longer than when depending on natural draft, especially where producer gas or other fuel is used that tends to deposit dust on the checker brick and to limit the length of time a regenerator may be used.

The first fire-tube boilers for waste-heat recovery were installed in the plant of the Illinois Steel Company at South Chicago, passing the gases through 3-in. tubes in two vertical passes for a total travel of 28 ft. Boilers of this same type were later installed with an economizer element as a third pass, in which the steam required to drive the induced-draft fan was about 10 per cent of the boiler output.

The first horizontal boilers were installed at the plant of the Bettendorf Company at Bettendorf, Iowa, and have $2^1/_2$-in. tubes, 20 ft. long. The boiler reported on above has 2-in. tubes, 18 ft. long. Three boilers at the United Alloy Steel Corporation, of Canton, Ohio, have 2-in. tubes, 18 ft. long. The Tennessee Coal, Iron & Railroad Company at its Fairfield plant has installed four boilers of this type, designed for two horizontal passes, of which only one pass of each boiler is installed at present. The second pass is designed to be used as an economizer element. Each boiler as installed has 5600 sq. ft. of water-heating surface in $2^1/_2$-in. tubes, and is built for a working pressure of 250 lb. As now operated, final gas temperatures are about 600 deg. fahr., with mass velocities of close to 11,000 lb. per hr. per sq. ft. of gas-passage area. The addition of the economizer element will reduce this to as low as 350 deg., depending upon feedwater temperature and surface installed.

Auxiliary Furnaces

In many cases there is a demand for an auxiliary furnace so as to utilize the boiler for direct firing by oil or other fuel in the event of the boiler's being needed while the furnace is out of service. In designing these furnaces the superheater must be protected against the high furnace temperature of direct firing, but the boiler is otherwise operated in the same manner as a waste-heat unit. Gas velocities through the tubes are of course much lower for the same output, and the increased ratio of heating surface to the weight of gas passing gives an excellent heat absorption at rates up to 4500 B.t.u. per hr. per sq. ft. of heating surface. No attempts have been made to operate continuously above this rate as it is feared that fire cracks would appear in the tube ends under the harsh action of excessively high temperatures in the front heads, although continuous operation at this rate has had no ill effect.

The auxiliary furnace must be designed to insure complete combustion of oil or gas before the products come in contact with the heating surface, and should have not less than 0.2 cu. ft. of furnace volume per square foot of water-heating surface in the boiler, and a flame travel of 20 ft. or more if possible.

Heat Recovery in Steel Furnaces

To show the effect of the recovery of waste heat from open-hearth furnaces on the cost of finished steel, the following example is taken.

In a modern steel plant consisting of eighty coke ovens, two 500-ton blast furnaces, and twelve open-hearth furnaces and rolling mills for producing track material, structural shapes, plates, wire, and rods, for every ton of finished steel there will be required 0.73 ton of coke, 0.73 ton of iron, and 1.27 tons of ingots.

The coke ovens and blast furnaces will furnish enough fuel for

their own operations, including steam, water, and power requirements. Excess coke-oven gas and blast-furnace gas is assumed to replace coal of 12,000 B.t.u. per lb., costing $4 per ton, including the cost of unloading, firing, and ash disposal, and utilized at 70 per cent boiler efficiency.

Source:	B.t.u. available in surplus fuel per ton of finished steel	Credit to cost
Coke-oven gas	2,390,000	$0.40
Tar	1,370,000	0.228
Coke breeze	1,000,000	0.168
Blast-furnace gas	4,000,000	0.66
Open-hearth waste heat	3,620,000	0.445

No modern steel plant would tolerate the waste of excess coke-oven gas, tar, coke breeze, or blast-furnace gas, although many plants are now burning coal or buying power while making no attempt to reclaim the tremendous heat losses incident to high stack temperatures in open-hearth and other furnaces.

Waste Heat in Cement Kilns

Cement kilns producing sufficient clinker for 1000 barrels of cement in 24 hours, yield about 83,000 lb. of waste gas per hour at a temperature close to 1100 deg. fahr. This is equivalent to 350 net boiler hp. per kiln. The authors do not know of any waste-heat installation of fire-tube boilers in this class of service, but it is thought that the use of a properly designed fire-tube unit would be especially desirable in this service on account of the well-known difficulty of keeping the heating surface of water tubes reasonably free from dust. Moreover, the volumes and temperatures of waste gases from these kilns are quite constant, and in a properly designed boiler the maximum heat-transfer rates could be utilized at all times and the combination of boilers, fans, and superheaters could be arranged to operate at or near the maximum on the combined efficiency-load curve.

Utilization of Internal-Combustion-Engine Exhaust Heat

Interest has also recently been revived in the problem of recovering heat from the exhaust gases of internal-combustion engines. The European countries are considerably ahead of us in this field, but through our European consultants we have kept in touch with developments.

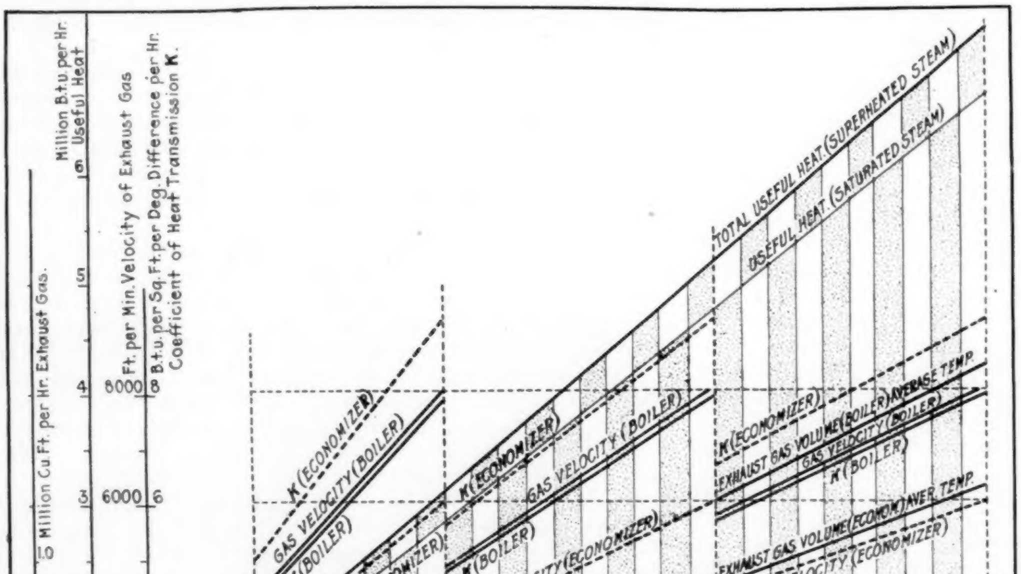

Fig. 2 Performance of Fire-Tube Boilers of Three Different Sizes Utilizing Exhaust Gases from Blast-Furnace-Gas-Driven Engines

Production of steam (170 lb. per sq. in., 573 deg. fahr.), 1.65 lb. per b.hp-hr.
Temperature of feedwater, 68 deg. fahr.
Temperature of exhaust gases entering superheater, 1020 deg. fahr.
Temperature of exhaust gases entering boiler, 940 deg. fahr.
Temperature of exhaust gases entering economizer, 509 deg. fahr.
Temperature of exhaust gases leaving economizer, 360 deg. fahr.
Engine load, 65 lb. per sq. in. Mechanical efficiency, 84 per cent, corresponding to 250 cu. ft. per b.hp-hr. piston-displacement suction.

Fig. 2 shows the performance of fire-tube boilers of three different sizes, utilizing various volumes of exhaust gases from engines using blast-furnace gas. These curves are developed from a large amount of actual test data on the three sizes shown, and clearly indicate that the coefficient of heat transmission increases directly with the increase in gas velocity in a given size of boiler tube. It is also of interest to note gas velocities as high as 8000 ft. per min. in utilizing the engine exhaust gases, whereas in using waste furnace gases the economic limit is about 4800 ft. per min. The possibility of such operation favors the application of waste-heat boilers to engine exhaust gas. High velocities may be reached by adding only slightly to the back pressure on the engines, which is not a serious consideration, while the power required in a suitable exhauster for such high velocities in ordinary waste-heat practice would be prohibitive.

In engines of this type there is an ordinary yield of 2 lb. of high-pressure superheated steam for each brake horsepower developed by the engine. In fact this figure, or one very close to it, is established so well for each engine that any increase in steam production is taken as an indication of incorrect gas-air mixtures in the cylinders and poor engine performance, rather than of any change in boiler efficiency. In each instance the boiler performance is thus a guide to the operators in keeping the engine up to its best efficiency.

A typical heat balance of gas engines is:

	Per cent
Useful work	33
Lost in exhaust gas	36
Lost in cooling water	29
Radiation and unaccounted for	2
	100

By utilizing the waste gases in a suitably designed boiler, and in addition using a portion of the hot cooling water for boiler-feed service, the total of 36 per cent lost heat is reduced to 11 per cent, and the percentage of useful work extracted from gas is increased from 33 to 40 per cent. This is undoubtedly the highest recovery of heat in any practical prime mover in industrial use.

Diesel oil engines are now being built in units up to 8000 hp., in which substantially 30 per cent of the heat value of the fuel is lost in the exhaust gases. There is little doubt but that the near future will see the installation of fire-tube boilers in connection with many of the larger internal-combustion engines.

Discussion

David Lofts[3] wrote to say that his company had several waste-heat boilers operating in connection with 25-ton open-hearth furnaces which had given good results. The boilers used had 3500 sq. ft. of heating surface and were of the Wickes vertical type with steel casing. They were used with both producer gas and oil as the fuel. In the more recent installations superheaters had been added and in future installations the use of economizers might be considered. The general results obtained were as follows:

On Producer-Gas-Fired Furnaces (Boilers without Superheaters):

Temperature of products of combustion from open-hearth furnace, 1200 to 1300 deg. fahr.
Temperature of products of combustion leaving boiler, 600 deg. fahr.
Average weight of steam made per hr., 6500 to 7000 lb.
Approximate boiler horsepower delivered at 34.5 lb. per hp. from and at 212 deg. fahr., 240 to 250.

On Oil-Fired Furnaces:

Temperature of products of combustion from open-hearth furnace, 1150 deg. fahr.
Temperature of products of combustion leaving boiler, 460 deg. fahr.
Average weight of steam made per hr., 5500 to 6000 lb.
Steam superheated, 120 to 150 deg. fahr.
Approximate boiler horsepower delivered at 34.5 lb. per hp. from and at 212 deg. fahr., 190 to 200.

The saving by the use of these boilers was represented by the cost to raise a similar amount of steam in the regular coal-fired boilers at the plants, less the cost of attendance, repairs, etc. on the waste-heat boilers, and could easily be estimated for any particular installations. In addition to the actual saving of coal, there were intangible savings due to better control of the draft and some reduction in time of making a heat.

W. J. Williams[4] said that the Edge Moor Iron Company specialized to a very large extent in the cement industry and were using a unit composed of a boiler, superheater, and economizer. The boilers had four vertical passes, with the superheater located either above the first pass or below the first pass, depending on the amount of superheat desired, and also the temperature of the gases as they left the kiln. The steel economizer was located under the forward pass, and was found to give less radiation loss than an economizer located at the rear. There was a large amount of dust contained in the gases leaving the cement kiln, particularly in the case of the dry process. He thought that the cement industry was making a mistake in its current practice of blowing a water-tube boiler once every 24 hours, by either a steam or an air hand lance, because air was much handier for the operator to handle than a hot steam hose. Further, they had found that it was sufficient to blow the first pass of the ordinary four-pass boiler once in every 24 hours and to leave the other three passes to be taken care of by the scrubbing action of the gases. All the draft came from the fan located beyond the economizer. They were quite successful in eliminating air leakage as a whole, but found that where the cement burners were burning an excessive amount of coal compared to the amount of air, some CO went back to the end of the cement kiln. There was also a slight percentage of air infiltration in the kiln housing, and this was sufficient to start up secondary combustion, which in turn would cake up slag on the first row of tubes.

One of the most interesting things in connection with the cement installations was the use of a common flue for a number of kiln housings, which admitted of interchangeability. In most cement plants they could get almost enough recovery to run the entire cement mill. With the dry process, where the gases came out at anywhere from 1200 to 1800 deg. fahr., they could recover, on the average, about 400 lb. of steam per barrel of clinker made. Under ordinary operation only 360 lb. of steam was necessary per barrel of clinker made. As a result there were quite a number of the cement companies that were selling power to the nearby towns as a by-product of their waste-heat systems. Mr. Williams referred to a statement made at the Portland Cement Association that any one who was paying more than three-quarters of a cent a kilowatt was losing money by not utilizing waste heat. He knew of only one case in the whole of the cement waste-heat recovery where there had been any excessive cutting, and that was in the installation of the Universal Portland Cement Company at Buffington. However, here beyond a doubt the cutting was due to the fact that they used blast-furnace slag in part of the mix, and it had a very abrasive action.

His company had just recently opened up a new and rather interesting field by installing some waste-heat boilers in connection with the waste gases of a pulp mill.

W. R. Chambers[5] said it was his feeling that any boiler was more or less applicable to waste heat provided that it was well set, preferably with steel casings, so there would be little air infiltration. In connection with boilers of oil-fired installations, where the gas temperature leaving the boiler was around 455 or 460 deg. fahr., he was quite sure that most of them would have a draft loss of only an inch and three-quarters.

Wm. B. Chapman[6] asked what temperature made a waste-heat boiler a commercially desirable proposition. Anything under 1100 deg. fahr. was probably impracticable. Abroad they only had temperatures of 700 deg. fahr. from their open-hearth furnaces and used no waste-heat boilers, because of a different construction of the regenerator. They built their regenerator deeper and thereby took up much more of the waste heat, and in doing this it was necessary to make the passages more open than ours; but as the gases rose up through the regenerator, in going into the open hearth, they came up with a greater velocity, because they came up a greater distance, and there was a greater heat interchange. These then went into the open-hearth furnace at more nearly the velocity of the producer gas, and therefore a better mixture was possible.

In his closure Mr. Willcox said that the velocities were figured at the mean average temperatures through the tubes.

In regard to the temperature at which a waste-heat boiler ceased to be profitable, he said that of course it seemed to be a thing that would require a different answer for every job. In figuring a job where the waste temperatures from the regenerators were as low as 800 deg., it was found that the installation would not pay. At 1000 deg. the installation usually seemed to pay, and from 1000 deg. up it was his experience that there was always a saving.

In regard to the length of time which waste-heat boilers could be kept in service, Mr. Wilcox told of a case where Mississippi River water was used at Davenport, Iowa. The water ran about 12 grains encrusted solids, was almost entirely carbonate, and had a good deal of mud in it. The six boilers would run as long as the open-hearth furnace—with good running, 400 heats—or, at the rate of, say, two heats a day, 200 days. Discounting this a little would give 180 days.

Probably no single inventor has within his lifetime seen as much publicity given to his patents as did Doctor Rudolph Diesel, and it has become the custom to apply the term Diesel to all engines having a compression high enough to ignite the fuel. Inasmuch as none actually operates on the Diesel cycle, why would it not be better simply to classify all as oil engines?

At present the purchaser, unless he has gone deeper into the matter than is usual, presumes that all are more or less alike, each being classified as a Diesel by its maker. It has the effect of lulling the buyer to sleep, and he fails to give the individual engine the close scrutiny it deserves.

If, on the other hand, the public, the engineering bodies, and the engine builders called these internal-combustion engines of automatic igniting ability simply oil engines, the purchaser would, perforce, be compelled to examine each engine offered to find out how it works. (*Power*, August 24, 1926, p. 290.)

[3] Chief Engineer, American Steel Foundries, Chicago, Ill. Mem. A.S.M.E.

[4] The Edge Moor Iron Co., Chicago, Ill.

[5] Assistant Chief Engineer, American Steel Foundries, Chicago, Ill. Mem. A.S.M.E.

[6] President, Chapman-Stein Furnace, New York, N. Y. Mem. A.S.M.E.

Interconnections in Virginia and North Carolina

Difference Between Interconnection and Superpower—Interconnection Agreements Normally in Use—Data on Actual Interconnections

By Wm. C. Bell,[1] Richmond, Va.

INTERCONNECTIONS between several of the electric-service companies in Virginia and North Carolina are now in operation, others are being constructed at this time, and still others are under consideration in connection with the normal expansion of the various power systems.

The growth in capacity and in area served requires the construction of new centrally located, efficient power stations, or the enlargement of existing ones, and the construction of lines to transmit the power to various parts of the systems and to interconnect the various systems, when they are so located that this can be done economically.

Interconnection and Superpower

Some confusion exists between the terms "interconnection" and "superpower," and a brief discussion of their accepted meanings seems proper before discussing the actual results which have been accomplished up to this time in the area under consideration.

"Superpower" seems to be accepted to mean those electric supply systems in which electrical energy is supplied over a relatively large area by transmission lines feeding the various load centers in the area, from relatively large high-economy power stations, in contrast with the older plan of operating small local generating stations supplying only the immediately surrounding territory. Of course, hydroelectric generating stations of various sizes can be efficiently operated on a superpower system, and even very small automatic hydroelectric generating stations can be economically connected to passing transmission lines.

A superpower system may be composed of several interconnected, adjoining, independently owned or controlled electric power systems, or may comprise a single large system owned or controlled by a single interest.

"Interconnection" seems to be accepted to mean the physical interconnection, by electric transmission lines, between adjacent transmission systems for mutual protection, and for interchange or transfer of electrical energy. Interconnections may, or may not, be steps in the establishment of a superpower system.

In Virginia and North Carolina the majority of the interconnections up to this time have been made primarily for the mutual protection of the interconnecting companies and the interchange or transfer of relatively small quantities of power, but insofar as they allow energy to be manufactured in the more efficient steam stations, rather than in smaller and less efficient stations, and allow hydroelectric generating stations to produce a greater amount of energy than would be possible without the interconnections, or to conserve available water for heavy load periods, these interconnections are helping in the development of superpower in Virginia and North Carolina.

General Classes of Interconnection Agreements

Arrangements whereby electrical energy is interchanged through interconnections can usually be placed in one of the three following general classes:

1 Those interconnections where a group of two or more companies tie their power systems together and pool the capacity available in order that electrical energy may be generated and distributed as though the interconnected systems were one large system.

In these cases, an equitable arrangement as to division of cost has been suggested and used in certain cases, whereby each of the interconnected companies is either paid by the pool a capacity charge, based on the amount of excess capacity above its own requirements available for delivery to the pool, or pays to the pool a capacity charge based on the capacity required from the pool for its own uses. A company having any excess of generating capacity can thus make it available to other of the interconnected companies who may at that period require capacity in addition to that from its own stations.

In addition to the capacity charges, which are adjusted at reasonable intervals, each company is paid by the pool for any energy delivered to the pool at a rate per kilowatt-hour made up of the fuel cost per kilowatt-hour for the particular plant in question, plus a small amount per kilowatt-hour for labor and repairs. Any company receiving energy from the pool pays the pool for such energy at the average cost per kilowatt-hour of all energy delivered into the pool during the period in question.

Such an arrangement makes it possible for one of a group of interconnected companies to construct a new plant and sell to the pool the surplus capacity available, while another of the interconnected companies can in turn defer the installation of additional capacity and pay into the pool for such additional capacity as it requires. This arrangement also encourages the operation of the most efficient units, since all of the interconnected companies may profit by lower fuel costs, regardless of the station in which the power is produced.

If an interconnection on the basis of pooling capacity and operating as a single large system is made between two companies, a rather simple contract will care for the adjustment of charges between the two companies at stated intervals, but if several companies are involved rather elaborate contracts are necessary in order to assure proper coördination in the construction of generating capacity and to provide the operating and accounting machinery necessary to carry out the details of the plan, or a separate company may be created by the interconnected companies to care for the transmission or generation of energy, or both.

2 Those interconnections where a group of two or more companies tie their systems together primarily for mutual protection and for interchange of surplus energy.

In these cases, energy is usually interchanged when available, as needed, and if agreeable at the particular time to both parties, with no obligation on the part of any of the interconnected companies to supply nor to receive energy at any time, although the spirit of the agreement usually contemplates that each company shall supply energy to the other interconnected companies up to the reasonable limit of its spare capacity available at the time, when called upon to do so.

Such interchange arrangements are justified by the fact that they will enable one company to help another in times of accident or power shortage, and will enable all of the interconnected companies to profit by the diversity existing between the loads of the various power systems, and will allow one company to dispose of surplus power to another company when it is mutually profitable or advantageous.

Rates under such an arrangement, often called the "when, as, and if" basis, are usually in the form of a flat rate per kilowatt-hour, high enough to cover ordinary operating charges of the seller, yet low enough to enable the purchaser to buy without seriously increasing his production costs. If a rate is established which is too high, then the buyer cannot afford to purchase energy, and he is forced to operate his own plant in order to keep down production costs, and the interconnection is then used only in cases of emergency. It is important that equitable rates should be established in order that the interconnections may be freely used with resulting maximum benefits to both parties.

3 Those interconnections which are made for the definite purpose of supplying capacity and energy to a company

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which prefers to buy a part or all of its requirements rather than to construct or increase its own generating facilities.

In these cases, the purchasing company becomes a power customer, and standard power rates should control the rate at which the power is sold. Conditions arise to vary the direct status of buyer and seller, such as the availability on the system of the purchaser of a surplus of power during certain hours of the day and certain seasons of the year, sometimes called "dump power." This condition arises in case a company operates hydroelectric stations for the production of a part of its requirements, purchasing power during low-water periods, and selling any dump power which may be available during good water periods. The payment for this dump power may be made as direct payment at a small rate per kilowatt-hour, or by some adjustment of the prime power rate to care for the conditions as they exist.

A further variation of the condition outlined in the previous paragraph exists in the case of large industrial power customers who may operate generating equipment of their own to produce a part of their requirements in connection with the production of process steam. In such cases, the customer may have dump power available at certain times for sale to the power company, and it may be of advantage to both the power customer and the power company that the power company absorb this dump power at a small charge per kilowatt-hour, not more than the fuel cost per kilowatt-hour of the power company.

Interconnections in Virginia and North Carolina

In Virginia and North Carolina the major portion of the electric service is supplied by eight companies; namely,

Appalachian Electric Power Company
Blue Ridge Power Company
Carolina Power & Light Company
Southern Power Company
Tallassee Power Company
Tidewater Power Company
Virginia Electric & Power Company
Virginia Public Service Company

The Appalachian Electric Power Company is now interconnected with other subsidiaries of the American Gas & Electric Company, with lines running north and west to Indiana and Ohio, and in West Virginia with the Norfolk & Western electrification system. The Appalachian Electric Power Company supplies a large area in Southwest Virginia, including Lynchburg, but is not at this time interconnected with other large companies in Virginia or North Carolina. A transmission line south from Roanoke to Danville has been completed as far as Martinsville, and an interconnection with the system of the Carolina Power & Light Company in North Carolina, by the construction of a line between Danville, Virginia, and Roxboro, North Carolina, is now projected by these companies.

The Virginia Electric & Power Company operates a power system in the eastern part of Virginia and North Carolina, extending from Fredericksburg, Virginia, to Tarboro, North Carolina, and east to Chesapeake Bay, including the cities of Richmond, Petersburg, Norfolk, Portsmouth, and Suffolk.

The Virginia Public Service Company operates four separate power systems in Virginia: the Northern Division, in and around Alexandria; the Western Division, in and around Charlottesville and Clifton Forge; the Southside Division, in the area between South Boston and Emporia; and the Newport News Division, in and around Newport News. While these four units are not at this time interconnected among themselves, certain of them are interconnected with other power companies. The Northern Division is now connected with the Potomac Edison Company at Washington, D. C., on the "when, as, and if" basis, and the Southside Division is now interconnected with the Virginia Electric & Power Company, as noted below.

The Virginia Electric & Power Company and the Southside Division of the Virginia Public Service Company are now interconnected at Roanoke Rapids, North Carolina, on a basis whereby the Virginia Electric & Power Company furnishes power to the Virginia Public Service Company during low-water periods, and purchases from the Virginia Public Service Company a certain amount of dump power when water-power stations are operating at full capacity. A second interconnection is now under consideration between the Northern Division of the Virginia Public Service Company and the Virginia Electric & Power Company north of Fredericksburg, Virginia, on the basis of a direct sale of a definite amount of power to the Virginia Public Service Company by the Virginia Electric & Power Company.

The Virginia Electric & Power Company is now interconnected with the electric system of the City of Richmond, Virginia, where the city operates two small hydroelectric plants with steam relay for municipal water-pumping and street-lighting requirements. This interchange of power is on the "when, as, and if" basis.

The Virginia Electric & Power Company and the Carolina Power & Light Company have recently entered into a contract under which an interconnection will be established between the two power systems by the construction of a line from Rocky Mount, North Carolina, to Battleboro, North Carolina, where interchange of power will be on the "when, as, and if" basis.

The Carolina Power & Light Company operates a power system in central North Carolina and in South Carolina, extending from the vicinity of Henderson, North Carolina, to Florence, South Carolina, and from Goldsboro, North Carolina, to Badin, North Carolina, including the cities of Raleigh, Goldsboro, and Fayetteville, North Carolina, and Florence, South Carolina. A small system is also operated in the western part of North Carolina in and around Asheville.

The Southern Power Company operates a large power system in North Carolina and South Carolina, doing principally a wholesale power business, by selling power to large users and to distributing companies, for resale to retail customers.

The Southern Power Company and the Carolina Power and Light Company now have two separate interconnections in North Carolina and one in South Carolina; one between Raleigh and Durham, North Carolina; one further south near Badin, North Carolina; and one in South Carolina at Wateree. These interconnections in North Carolina are on the "when, as, and if" basis, and the one in South Carolina at Wateree is on the basis of a direct sale of a definite amount of energy. The Southern Power Company is interconnected with the system of the Southeastern Power & Light Company in Georgia and Alabama.

Both the Carolina Power and Light Company and the Southern Power Company are interconnected with the Tallassee Power Company at Badin, North Carolina. The Tallassee Power Company operates large hydroelectric generating stations near Badin, North Carolina, the majority of the output being used in the manufacture of aluminum.

The Tidewater Power Company, operating in the City of Wilmington, North Carolina, and in the section of North Carolina north and west of Wilmington, is interconnected with the Carolina Power & Light Company at Mount Olive, North Carolina, on the "when, as, and if" basis.

When the interconnections now under construction between the Carolina Power & Light Company and the Virginia Electric and Power Company are in operation, and if the contemplated interconnection between the Virginia Public Service Company at Alexandria and the Virginia Electric & Power Company at Fredericksburg is completed, there will be only the short interconnection between the Appalachian Electric Power Company and the Carolina Power and Light Company south of Danville, to connect all of the major electric systems in the South Atlantic States of Virginia, North Carolina, South Carolina, Georgia, and Alabama.

Advantages of Interconnection

The advantages of interconnection have been so often stated that it is hardly necessary to mention them again, but in order that the outstanding advantages may be available for those who are not closely interested in the electric service business some of the advantages are given below:

1 Added reliability and increased economy. In case of shortage of water power, or accident to generating equipment, other equipment on the interconnected systems can supply power until conditions become normal, repairs are made, or other units put in service. The most efficient units can be run under most efficient conditions, the least efficient units being used for shorter periods and for reserve.

2 Increased diversity, causing lower aggregate peak requirements over the combined systems, and thus improving the load factor on the systems interconnected; requiring less plant investment, due to lower aggregate peak load.

3 Common use of reserve or spare capacity, thus reducing plant investment in reserve or spare capacity.

4 Larger annual output from hydroelectric generating stations, due to the fact that the hydroelectric stations can be operated at full load continuously when water is available, whereas a smaller system might not have sufficient demand at all hours to allow full operation, and this would, of course, result in a waste of water.

5 General availability of power in adequate, dependable quantities over large areas, making it possible for factories to locate where raw material, labor, market conditions, etc., are most favorable. This is particularly important where manufacturing plants can be constructed in smaller towns and agricultural areas, in order to use female labor and labor normally employed during certain seasons only, and available for work in manufacturing plants at other times. Interconnection is, in this manner, an active force in the decentralization of population.

The Division of Labor in Tool Manufacture

BY G. A. PENNOCK,[1] CHICAGO, ILL.

IN THE MACHINE shops of large plants the main contributing factor toward the elimination of waste during the past years has been the gradual drawing away from the use of the all-around craftsman, skilled in all phases of tool making, and toward the development of specialists in the various machine and bench operations.

In 1895 the Western Electric Co. had just one type of employee, "the tool maker,"—the all-around craftsman, who was expected to handle any job that came along. Today this company has 10 general types of employees engaged in tool manufacture, ranging from planning engineers to machine hands.

The method of making a tool in 1895 was about as follows: As a rule no tool drawing would be furnished. Sometimes a sketch showing the outline of the tool would have been made. In other cases a sample or drawing of the part to be made would be all the information the tool maker had to work on.

After receiving the material necessary to build a given tool he would proceed to lay out the work. Next he would do all the necessary machine work and then proceed to the work of fitting. Practically all die sizing and fitting was done by hand. After the die had been hardened the punch was milled larger than the die opening and fitted by repeated shearing and filing.

Practically all locations of any importance would be laid out with the aid of a gage block, scratch awl, scale, and, in some very rare cases, by the use of blocks that had previously been made to length with the aid of a micrometer.

It frequently happened that the tool maker found several others waiting to use the one available milling machine or lathe. Proper supervision could, of course, eliminate this to a large degree, but the condition always existed to some extent.

The work today is divided into (1) planning, (2) tool designing, (3) tool ordering, (4) actual manufacturing.

Instead of the tool maker the planning organization now determines the kind and type of tool to be made, based upon the annual demand for the part, and involving tools ranging from the simplest to the most efficient multiple compound and multiple forming tools.

This division is divided into four departments, namely, the punch and die department, the jig and fixture department, the gage department, and the screw machine tool department. The designers in each of these groups work almost entirely upon one particular type of tool, which tends to produce a more efficient design and lower design cost.

Considerable progress has been made in the standardization of our tool designs, thus eliminating the necessity of making a complete tool design for each tool, and standard designs have been made showing the complete standard tool.

From the tool design division, the tool order, together with drawings, goes to the tool-ordering organization. This organization checks the estimated cost of the tool, orders standard commercial parts, if any are required, places orders for patterns, castings, or forgings, as the case may be, and follows these orders to insure delivery to the tool-room. It also writes up the order, giving a complete description of tool, final estimated tool cost, a description of the part to be made, etc., and forwards it to the shop with the drawings attached.

In the shop we find specialization of work or division of labor carried to a greater degree than in the tool design division. The tool-room is divided into the following main groups: the milling machine section, the lathe section, the grinding section, and the bench work section. These main groups are still further subdivided as follows: In the lathe section we have specialists on threading plug gages and master taps and still others who turn only circular form tools. The bench work section is subdivided into punch and die work, gage work and general tool work, which includes drill jigs, assembling and milling fixtures, screw machine tools, etc., and in the die gang we have compound die makers, tandem die makers and forming die makers, who perform only the bench work necessary in the building of these dies.

Upon the receipt of an order in the tool-room a record is made of it and the necessary raw material and standard parts already referred to are drawn from stock. The order, work ticket, and material are then passed to the proper department. The material and work ticket are then forwarded to the machine departments for the necessary machining. From there they are returned to the die department, if the tool to be made is a die, where the fitting is done. The parts are then hardened by a specialist and returned to the die maker for the final fitting and assembling.

In this manner, then, every operation has been carried out by a man skilled in that particular work to such a degree that a minimum amount of time is required in setting up work, and greater speed and accuracy assured. Further, as the various operations require varying degrees of skill and craftsmanship, help of a lower grade than the old time tool maker can be employed on many of them, resulting in lower labor costs.

Upon the completion of the tool, it is routed to the tool inspection organization, in which is required not only ability to interpret drawings and to make measurements with infinite accuracy, but technical understanding and a sense of the proper and economical use of tools and of the inspection gages to be employed. Not only must the part be produced according to the drawing, but it must be correct for subsequent operations. Tool inspection has also become a specialized task and in this instance again the advantage is a high grade of work at a lower cost.

A comparison of costs by present methods with the old way is rather difficult, but the following case will serve as an illustration. Let us take a theoretical punch and die and estimate the labor hours required for the various operations under both methods, using \$1.00 an hour as a basic rate for a tool maker and corresponding rates for the various machine operators.

	Old Method		New Method	
Lathe work	9 hr. at \$1.00 =	\$ 9.00	6 hr. at \$0.75 =	\$ 4.50
Milling work	10 hr. at 1.00 =	10.00	8 hr. at 0.60 =	4.80
Drilling work	8 hr. at 1.00 =	8.00	5 hr. at 0.50 =	2.50
Grinding work	5 hr. at 1.00 =	5.00	3 hr. at 0.80 =	2.40
Hardening	1 hr. at 1.00 =	1.00	1/2 hr. at 1.00 =	0.50
Bench work	20 hr. at 1.00 =	20.00	20 hr. at 1.00 =	20.00
Totals	53 hr.	\$53.00	42 1/2 hr.	\$34.70

From this it is evident that the new method consumes only about 80 per cent as much time as the old with a reduction in tool costs of approximately 35 per cent.

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The Design of High-Pressure Industrial Power Plants

Boilers Operating at 425 Lb. Pressure Pass All Steam Through Turbine and Exhaust into Steam Header to Supply Mills at 130 Lb.

By R. S. Baynton,[1] West Point, Va.

THE MODERN tendency toward the use of high steam pressures in utility-plant practice, which has been so marked a feature of the development of such plants during the past decade, has its counterpart in the more conservative industrial power plant; and in industries such as the pulp and paper, sugar, soap, artificial silk, etc., which use large quantities of steam for process work at various pressures, it will lead to economies which are nothing short of revolutionary. In the plant described in this paper, the cost of electric power, already low, has been reduced 80 per cent, the present cost in B.t.u. per kw-hr. being only half of that of the best public utilities, this of course being due to the complete utilization of the exhaust steam in process work instead of the rejection of the major portion of the heat to the condensers. The electric and steam power are thus almost wholly obtained as a by-product and at very high efficiency. The whole capital cost of the plant will be returned in less than three years, and the net saving in the cost per ton of product will be approximately equal to the average net profit available for dividends; in other words, the saving will nearly double the company's profits.

It is the author's desire to point out that the design of an industrial power plant of the new style, though the plant may be comparatively diminutive from the standpoint of the public utilities, must be carefully studied so that it may exactly fit all the conditions.

General Lines of Design

In any industrial works requiring both power for driving machinery and steam for process work the maximum economy is obtained by selecting such a steam pressure and superheat for the boiler plant as will permit all the power required to be obtained by passing all the steam through turbines or engines which will deliver to each of the various processes the steam required at the correct pressure and temperature. No steam must be reduced to a lower pressure without being used for power generation, and no heat must be rejected to condensers or to atmosphere. Briefly, all power must be generated as a by-product, no heat degraded, and none rejected to waste; using all exhaust in process work.

The ideal being thus defined, it remains to ascertain how best to approach this ideal in any particular case, and how to cope with fluctuations that necessarily occur both in the demand for electrical power and for steam at various pressures.

Application of General Principles to Typical Design

To this end, the author proposes to describe, in more or less detail, a new power plant designed by him for a large industrial corporation, in which the principles set forth above have been carried to what he conceives to be their practical limit for this particular case.

The old boiler plant consisted of five 300-hp. and one 400-hp. stoker-fired Wickes boilers, one 300-hp. hand-fired B. & W. boiler, and a 150-hp. horizontal return tubular boiler for refuse disposal. The prime movers were two turbines of 750 kw. and 500 kw. respectively, and four engines of 100 to 400 hp.

The products of the mill are of two kinds, which may be designated as "A" product and "B" product. The production had been increased each year until it averaged, during 1925, seventy tons of "A" product and forty tons of "B" product daily, and it was desired to provide capacity in the new plant for making a hundred tons per day of the "A" product, and fifty of the "B" product.

The old plant was too small to provide such an output, and was also near the end of its useful life after twelve years of service on a twenty-four-hour basis. It would hardly pay to make a small increase in capacity, and extend on the existing lines.

It was therefore decided to get out a complete design for a new power plant, having it in view to obtain the maximum possible efficiency by the use of the most modern methods consistent with reliability and economy of capital expenditure.

The main lines of the scheme were to install sufficient new boiler plant to deal with the whole load of the mill, scrapping all the old boilers with the exception of that used for refuse disposal, and to rearrange and partially renew the prime movers. A new power-plant building, with coal- and ash-handling plant was included in the scheme.

The object of the investigation was to determine whether the economies which could be effected would justify the capital expenditure. Careful research was necessary to ascertain the lowest pressure possible to select for satisfactory operation of that portion of the plant which it was proposed to retain; the amount of superheat which could safely be allowed in the supply also had to be settled.

The Rankine efficiency which could reasonably be anticipated for the high-pressure turbine had to be determined, and with all these factors in view a series of calculations was made to determine the power available from the steam while being reduced from the various high and medium pressures and superheats to the selected exhaust pressures and the condition of steam at exhaust.

In the present case a Rankine efficiency of 57 per cent was assumed—afterward it was found to be closely in accordance with that offered by the turbine makers for the actual machines—and calculations were made for pressures between 275 and 550 lb. by steps of 25 lb., and for superheats of 50 to 200 deg. fahr. by steps of 50 deg. fahr.

It was found that for the average steam and electrical demands which would exist in the new plant after the extensions and for the increased production, the best steam conditions were 425 lb. pressure and 100 deg. fahr. superheat, and that, assuming such conditions, an almost perfect heat balance for the entire plant could be obtained during average running, and maintained over a reasonably wide deviation from the normal, while at the same time provision could be made to cope with all unusual conditions and emergencies.

Main Outlines of Design

For supplying both medium-pressure steam and electrical power in widely varying quantities, it is essential, if such a scheme is to operate satisfactorily, that one of three main lines of design should be followed:

(*a*) A steam accumulator may be installed to take care of the fluctuations. This is expensive, cumbersome, and essentially inefficient from a thermodynamic point of view, and is unnecessary, as there are better alternatives. With very large and rapid fluctuations such an installation may be justified, but the time element is the controlling factor.

(*b*) A bleeder turbine large enough to supply all the power required may be used, the requisite amounts of steam being bled off at the various pressures as needed. This method has some attractive features at first sight, especially as regards simplicity of control, but was discarded for the scheme set forth below. In the first place a bleeder turbine is essentially a compromise in design, and either the high- or the low-pressure stages must suffer. Moreover there is a decided difficulty in taking off steam at a pressure that is at all high in comparison with the initial pressure. The machines of this type offered by the makers would have given an appreciably lower plant efficiency than the combination of

[1] The Chesapeake Corporation.

For presentation at the Old Dominion Meeting, Richmond, Va., Sept. 27–30, 1926, of The American Society of Mechanical Engineers.

straight exhaust turbine and medium-pressure bleeder turbine. Also, the capital expenditure would have been higher, assuming the same capacity and stand-by plant.

However, the chief factor that decided the choice was the question of emergency running in the event repairs were necessary to the high-pressure end. If the bleeder turbine were out of commission the whole mill would be down, whereas in the third scheme, with the high-pressure exhaust turbine out of service (which should seldom be the case owing to its simplicity of design), the two 750-kw. medium-pressure units included in the design would keep the mill going on 130-lb. steam supplied by the boilers through the reducing valves or by operating at reduced pressure.

(c) The third scheme is to employ a high-back-pressure turbine or turbines, taking all the steam generated by the high-pressure boilers and exhausting into the medium-pressure steam header at the minimum necessary pressure, operating in parallel on the electrical side with a medium-pressure turbine or turbines supplied from the high-pressure exhaust.

The governing of the high-pressure units must be directly controlled by the pressure in the medium-pressure header, the ordinary speed governor being held in reserve and never coming into operation under normal conditions.

This system is automatically self-balancing for all ordinary variations either in the demand for medium- or low-pressure steam or for electrical power, the load shifting from one turbine to the other as required. Thus, consider the case where, the electrical load remaining constant, there occurs an increase in the demand for medium-pressure steam. The pressure in the 130-lb. line will immediately start to drop, whereupon the governor of the high-pressure turbine will open and admit more high-pressure steam; this will result in an increased load being taken by this set, which will in turn relieve the low-pressure turbine of a portion of its load, setting free the 130-lb. steam it was previously taking to assist in supplying the increased demand. Correspondingly any alteration in the electrical load will be automatically cared for, and so the whole system will itself take care of normal fluctuations and only very unusual conditions have to be met by hand control or the use of steam through the reducing valves, installed for such emergencies.

A necessary feature of this scheme is that the two turbines must not be fully loaded, which makes it desirable that they should be designed to give as flat a water-rate curve as possible. This partial loading of the turbines, and consequent increase of the capital cost for a given desired capacity, however, applies also to the scheme employing bleeder turbines.

This system offered many advantages for the purposes of the particular plant under consideration and was adopted.

Having decided to install high-pressure boilers, it became necessary to insure perfectly pure feedwater, for with such pressures priming dangers are greatly increased, owing to the smaller drums of such boilers, the greater density of the steam, and the greater danger incurred should priming actually occur; a further point to be taken into consideration was the highly alkaline nature of the make-up water, which is from artesian wells and contains from 18 to 21 grains of equivalent sodium bicarbonate per gallon. Again it had to be remembered that it was proposed to run the boilers in certain circumstances at high ratings. Great trouble had always been experienced in the old plant owing to priming, sounding a note of warning which it would have been fatal to disregard.

The alkaline nature of the feedwater makes suitable treatment a matter of some difficulty, and while it might be possible to find a number of systems which would more or less offer a remedy, it was felt that the only reliable method of getting perfectly pure water for the boilers was by the employment of evaporators for the whole of the make-up.

This at once raised a serious problem of economy; the proportion of make-up is very high, averaging 20 to 25 per cent, on account of the use of steam in process work, and it became essential to find a method which would involve the minimum of thermal loss coupled with the minimum degradation of heat.

Inquiries from two leading manufacturers of such apparatus evoked nothing better on the one hand than the suggested use of exhaust steam for the evaporators, and on the other than the installation of a single-effect evaporator taking steam from the 425-lb. line, and exhausting into the medium-pressure header at 130 lb. The first plan involved the loss of a large amount of heat which could be profitably employed elsewhere without rejection of heat to the condenser, and the other, while subject to little thermal loss, did involve a serious degradation of heat, a loss of availability of heat units which were required to give power.

The plan finally adopted was to install a three-effect evaporator taking steam from the 130-lb. line, which had already done work in the high-pressure turbine, and condense the vapors from the third effect with the boiler feedwater, thus recovering all the heat units, and carrying them back to the boilers, and also permitting about 160 kw. to be extracted from the steam on its passage through the high-pressure turbines. The number of effects necessary in the evaporator is determined by the percentage of make-up and the temperature of boiler feedwater available.

It was found that the feedwater would leave the evaporator high-heat-level condenser at about 260 deg. fahr. and a further improvement in the feed system was made by the addition of a stage heater taking steam from the 130-lb. header, which would raise the feed temperature to 350 deg. fahr. and allow of the generation of a further 70 kw. from the steam necessary for the purpose. This alone would result in an economy of about 2 per cent of the coal bill at a trifling cost.

The question of pure feed being thus satisfactorily settled, the next problem to be faced was that of the extraction and utilization of all possible heat from the flue gases. Economizers were regarded with disfavor from the first, since one of the points aimed at was to have as small an amount of piping and apparatus as possible under the high pressure, and they were rendered impossible by the arrangement of the evaporator plant. This obviously called for air preheating, and to obtain the greatest efficiency and turn the gases out to the stack at a reasonably low figure (260 deg. fahr. was the temperature finally arranged) it was decided to install air preheaters of such a size as would deliver the air to the furnaces at 400 to 450 deg. fahr. This is considerably higher than most installations of the kind are designed for, but the trend of practice during the past year or two has been in the direction of higher temperatures.

However, the decision was not arrived at until very careful investigation of existing plants had been made, and the working conditions in the new plant brought into consideration. The design of combustion chamber and the arrangement of the baffles were specially considered with the high temperature of the air in view, and it was decided that whatever type of boiler should ultimately be selected, the baffling should be such that the whole length of the lower rows of tubes should be exposed to the direct radiation from the fires, as in the so-called "Alert" type of baffling in the B. & W. boilers, and this, combined with the moderate ratings at which the boilers were normally to operate, would, in the author's opinion, largely counterbalance the increase in furnace temperature due to the preheated air. Further precautions were to be taken in the shape of ventilated side walls to a suitable height above the fire zone.

Description of the New Plant

The building is conveniently situated at the southeast corner of the mill, and is of steel-frame and hollow-tile construction, stucco covered from the firing floor up, this floor being placed twelve feet above ground level; the basement is used for ash hoppers of such capacity as will permit the ashes formed through the night to remain till next day, and then be removed by the two men who handle all the coal and the ashes from both shifts. Two men thus replace nine under the old system. The evaporators, feed pumps, and other auxiliaries are also placed in the basement.

The construction below the firing floor level is of reinforced concrete throughout.

There are installed three 494-hp. Walsh and Weidner boilers operating at 425 lb. steam pressure, with Foster superheaters giving 100 deg. fahr. superheat. Westinghouse new-pattern five-retort, 18-tuyere underfeed stokers designed to burn coal of 13,750 B.t.u. and 10 per cent ash, and capable of 300 per cent rating on the boilers, have been put in, but it is proposed that the normal rate of operation shall be only 200 per cent for maximum economy to minimize trouble with refractories.

The air preheaters are of the Ljungstrom rotary type and have

the excellent performance to their credit of supplying air to the boilers at 400 deg. fahr. while passing the gases to the stack at 260 deg. fahr. The forced- and induced-draft fans are integral with the heater, and are mounted on the same shaft and driven by a 100-hp. General Electric slip-ring motor, with rheostat control; the power required to drive the fans at 200 per cent rating on the boilers is 20 hp.

The preheaters are set on the tops of the boilers instead of the more usual position at the back, and the whole of the top of the boiler room, which is distinct from, and higher than, the turbine room forms a closed box, so to speak, whence the fans draw their air. The consumption of air is such that at normal loads all of the air in the boiler room is drawn through the fans in five minutes, and thus there is a continuous and ample circulation of air from the turbine room, taking the hot air discharged from the generators to the lower parts of the boiler room, thence up to and through the preheaters, carrying with it the hot air from the boiler settings, and effecting a marked regenerative action with corresponding economy. Advantage has been taken of the possibility of recovering most of the heat lost by conduction and radiation from the settings by the use of hollow ventilated side walls. This should by its cooling effect on the furnace linings improve the life of the refractories, and is opposed to the more usual practice of placing special heat-insulating bricks to keep the heat in.

The Diamond soot blowers are supplied from the 130-lb. line with steam which has already done work in the high-pressure turbine.

Bailey boiler meters, pyrometers, and draft gages are fitted to each boiler, and a check is afforded by a Brown electrical CO_2 recorder, which can be switched on to any boiler. Flow meters are placed in the principal steam lines for the correct apportionment of the costs.

Hagan control is installed to regulate the fan speeds, according to the steam pressure, and to maintain a suitable draft over the fires.

The three-effect evaporator plant of the high-heat-level type described elsewhere was made by the Griscom Russell Co., and as an emergency supply, acid-treated water will be fed to the boilers from a Cochrane water-treatment unit.

There are two five-stage centrifugal Cameron boiler feed pumps of very heavy and rigid construction; each is capable of delivering 240 gallons a minute against a head of 1100 feet. They are arranged for dual drive, normally by electric motor, the work being automatically taken over in the event of any failure by a Westinghouse steam turbine supplied from the 130-lb. line.

Copes tension-type feedwater regulators with pump governors are installed, and the feed range is run in a modified ring system, for security of supply. The pipes are of very pure iron, to minimize corrosion. The high-pressure steam lines are jointed throughout with welded flanges, except that the valves are left free, for easy removal in case of necessity.

The coal- and ash-handling equipment, constructed by the R. H. Beaumont Co., is of simple design, but calculated to give maximum reliability of supply with a minimum of labor cost. It consists of a track hopper and automatic feeder leading to a double-roll crusher and a chain conveyor taking the coal up to a 150-ton circular steel-plate bunker placed outside the boiler house. A traveling weighing larry is used to convey the coal to the boilers. Considerable saving in capital cost was effected by the adoption of this form of storage over the more usual method of placing an overhead bunker in the boiler house. Ground storage is used to provide a supplementary supply of coal.

Water storage is provided by three 18,000-gallon circular tanks, placed on an elevated concrete structure adjacent to the coal bunker, and these are used respectively for condensate, acid-treated water, and raw water.

In order to provide for exceptional conditions, when the supply of 130-lb. steam from the high-pressure turbine, owing to a temporary falling off in the demand for electrical power, or an abnormal demand for low-pressure steam, should be insufficient, a complete reducing-valve system in duplicate, with a desuperheater, has been installed. The system includes an 8-in. reducing valve, for normal operation, with double shut-off and an intermediate drain on both inlet and outlet to permit overhaul while steam is in the line, in spite of possible leaky valves. This is supplemented by a 6-in. reducing valve for stand-by, with single shut-off. On the outlet a manifold with four safety valves is installed to protect the medium-pressure line, and from that the steam is led through a 14-in. Elliott surface-type desuperheater, water for which is provided by a pump having a capacity of 12 gallons a minute.

The turbine room has at present two turbines installed; the one high-pressure unit is a 1500-kw. Westinghouse high-back-pressure turbine, taking steam at 420 lb. and 100 deg. fahr. superheat, and exhausting at 130 lb. to the medium-pressure steam header. This is coupled to a 550-volt, three-phase, 60-cycle generator, running at a speed of 3600 r.p.m. At full load the water rate is 60 lb. per kw-hr. and at 1000 kw. is 61 lb.

The other turbine set is a medium-pressure bleeder and condensing set of 750-kw. capacity, taking steam at 130 lb. and 50 deg. fahr. superheat, with a water rate, condensing, of 17 lb. per kw-hr. It has been specially designed for maximum efficiency as a bleeder unit, as it is not expected to reject more than a very small proportion of the steam to the condenser.

The conditions of parallel running of these sets have already been considered.

A third set will be provided by the existent General Electric 750-kw. turbine, which will be moved from its present site in the old plant and reërected in the new turbine room. This will permit the two 750-kw. sets to be run on low pressure should the high-pressure unit be out of service, thus keeping the greater portion of the mill in operation.

The switchboard provides for three generators and six feeders. A voltage regulator to control three generators has been installed. All the oil switches are located in the basement, and ample room is provided for access to all parts.

Steam and Power Demand

In preparing estimates of the varying amounts of steam required to be furnished under different conditions by the high-pressure turbine to the 130-lb. header, and likewise the fluctuations in the electrical load, the method followed has been to set down the individual minimum, average, and maximum demands for steam and power for each department, and assuming the severe condition that all the minimum demands may occur simultaneously, and that likewise all the maximum demands may come on at the same time, obtain thus the range of variation in the amount of steam to be supplied.

It would be out of place here to enter into details of the above investigation, and it is sufficient to state that it was decided to drop the 500-kw. turbine from the old plant, replace certain of the old engine drives by electric motors, retaining such of the engines as were required to provide exhaust steam for process work, and thus improve the heat balance to the greatest possible extent.

Having made these rearrangements, it was calculated that the demand for steam at 130-lb. pressure, apart from that required for the 750-kw. turbine, would vary from a minimum of 44,000 lb. per hr. through an average of 63,000 lb. per hr. to a maximum of 78,000 lb. per hr. and that the electrical load would average 1500-kw., with irregular fluctuations.

These varying demands for low-pressure steam and electric power are met by varying the proportion of load automatically between the high-pressure and the medium-pressure turbines, as shown above.

Taking the steam consumption of the 750-kw. turbine to range from 8000 lb. per hr. minimum to 13,000 lb. per hr. average and 19,000 lb. per hr. maximum, we have

Minimum demand for high-pressure, lb. per hr....	44000 + 19000 = 63000
Average demand for high-pressure, lb. per hr.....	63000 + 13000 = 76000
Maximum demand for high-pressure, lb. per hr...	78000 + 8000 = 86000

This average is reduced by 4000 lb. per hr. by the supply from the low-pressure trash boiler mentioned earlier, so that the net average demand on the 1500-kw. turbine is 72,000 lb. per hr. from which about 1180-kw. is obtained at a very high efficiency.

Savings Effected and Comparative Figures

The following calculations and comparisons are based on a standard output of 150 tons of product a day, both for the old plant and

the new, it being thus assumed that the old plant would have been extended on the same lines to enable it to cope with such an output.

Coal Consumption—New Plant. The guaranteed combined efficiency of the boilers, superheaters, and air preheaters, with the stokers as installed, is 85 per cent. The author has assumed as a basis of calculation a twenty-four-hour efficiency for normal running of only 78 per cent. At the same time the efficiency for the old conditions is taken at 67 per cent, certainly not on the low side, so that the net estimated improvement of from 67 to 78 in substituting the most modern equipment for the old out-of-date and overworked plant will probably be exceeded.

On the above lines, the daily coal consumption would be 68 tons, and allowing 32 tons for week-end running and losses, the weekly coal used would be 440 tons. The annual cost would be $108,000. Similarly, for equal production, the old plant would consume annually coal to the value of $200,000, the saving on this item being $92,000 per year. It is estimated that a further saving of $11,000 per year will be effected by burning a cheaper grade of fuel, as the old plant required coal of the highest quality, and correspondingly high price.

Repairs. The repairs bill of the old boiler and stoker plant was excessive, and a moderate estimate has been made of saving 60 per cent of the expenditure on those items, reducing it from $30,000 to $12,000 per year, a saving of $18,000 per year.

Operation Wages. The staff for the old plant has been reduced by fourteen men—firemen, ash rollers, and coal passers—with a net saving of $20,000 per year.

The operating material, depreciation, and burden costs have been taken as remaining unchanged.

Comparative Costs on a Basis of 46,800 Tons per Year Output

On the above lines, the power cost for the new plant would be $163,500 per year, whereas for the old plant extended on existing lines it would be $300,000 per year, a net saving of $136,500 per year.

Capital Costs

The estimated cost of extending the old plant to cope with the desired increase of output was $80,000; the new plant cost well under $350,000 so that the whole capital will be returned in less than three years.

Miscellaneous Figures

Power cost per ton of product	
1920, old plant	$13.21
1925, old plant rearranged	6.95
New plant, estimated	4.05
Coal per ton of "A" product, lb.	
1920	2110
1925	1360
New plant	734
Cost of electric power, cents per kw-hr.	
Old plant, 1920	1.0
Old plant, 1925	1.11
New plant	0.19

A New Steam Chart

By the courtesy of the British Electrical and Allied Industries Research Association, we have received an advance proof of the new steam chart prepared for the turbine section of the Beama. The chart has been plotted by Professor Callendar from the data contained in his enlarged steam tables, which give the properties of steam at pressures ranging up to 2000 lb. per square inch. These tables are taken as standard by British engineers, and the new chart forms a fitting, not to say necessary, complement to them. Like the tables, the chart is based on the foot-pound-Fahrenheit system of units. It is essentially a "Mollier" or "total heat-entropy" diagram, but besides containing the usual lines of constant pressure, constant dryness fraction, and constant superheat, it has also lines of constant volume and constant total temperature. Moreover for absolute pressure below 2 lb. per square inch, there are additional lines corresponding to vacuum measured in inches of mercury. For ease of reading, the lines and figures relating to volume and superheats are printed in red, while the lines of vacuum are dotted.

Exclusive of margins, the chart measures 31.5 in. long by 26 in. high, the longitudinal scale being that of total heat and the vertical scale that of entropy. To facilitate the use of the chart, it is printed upon a background ruled with millimeter squares in faint blue. On the longitudinal scale, 1 mm. corresponds to a difference of 1 B.t.u. per lb., and on the vertical scale 5 mm. corresponds to one-hundredth of an entropy unit. The chart deals with steam ranging from 2000 lb. per square inch at a temperature of 1000 deg. fahr. down to a vacuum of 29.6 in. It is published by Edward Arnold and Co., at the price of 4s. net.

The publication of this chart provides engineers for the first time with a diagram by means of which they can obtain rapid and graphic solutions of problems relating to the use of steam at the highest pressures and temperatures which are in use or even under consideration today. Since Mollier first devised total heat-entropy diagrams, their use has become indispensable, and there was an urgent need for one which would cover the range of modern pressures and temperatures. Moreover, the auspices under which the present chart has been produced are sufficient to inspire confidence in its accuracy, so that it cannot fail to meet with a cordial reception.

That the form in which it appears has been the subject of earnest consideration by a competent body of men cannot be doubted, yet in view of previous practice, one may be permitted to question the wisdom of certain details. The quantity most commonly sought from such a diagram is the heat rendered available as work by a fall from a higher pressure to a lower one. This "heat drop" is read most naturally on a vertical line, and to enable that to be done, the total heat scale must be vertical instead of horizontal, as in the present case. In the total heat-entropy chart, ranging up to 750 lb. pressure, recently published in Mechanical Engineering, the heat drop is read vertically, and that is not only the obvious and sensible thing to do, but we believe most engineers will find a diagram confusing in which it is not done. It is true that in a most excellently proportioned and widely used total heat-entropy diagram published a good many years ago by Moyer, the total heat scale was horizontal, but even then Moyer did the next most natural thing and made the heat drop read from left to right. For no apparent reason whatever, on the new Callendar diagram heat drop has to be read, not only horizontally, but also from right to left, so that the chart has an unfamiliar and confusing appearance whichever way one may turn it around. This, perhaps, is a small point, and one which users may soon adapt themselves to, but to those accustomed to the conventions it is somewhat puzzling at first. (*The Engineer*, August 27, 1926, p. 222.)

The evolution of blast furnace fuels is interesting. Charcoal was the principal fuel for centuries, and in America it was but natural that it should be used, for timber was plentiful and much of it had to be cut to clear the soil and for building. Both raw coal and coke, however, had been used, for smelting iron ores prior to 1651, but in this country charcoal was first used exclusively and it was not until 1855 that anthracite iron passed charcoal iron; in 1869 bituminous fuel also passed charcoal, but taken together they only equaled the production with anthracite coal. In 1875, bituminous fuel passed anthracite and has now become the principal fuel. Originally this was all beehive coke, but this reached its maximum production in 1916, only to be passed by by-product coke in 1919, and today only one-quarter of the coke used is from beehive ovens. By-product coke making has increased fortyfold in twenty-five years. For the last year the figures are available, over 49 million net tons of coal were used in by-product ovens and the by-products had a value of $103,840,550, or about one-half the value of the coal used. (*Industrial & Engineering Chemistry*, Sept., 1926, p. 914.)

Transmission of Power on Oil-Engine Locomotives

Discussion of Paper by Alphonse I. Lipetz—Comparative Opportunities in Developing Designs Afforded European and American Engines—A Turbo Transmission Described and a Differential Elastic-Fluid Transmission Analyzed—Need for Large Power Locomotives

THE FOLLOWING discussion refers to a paper by Alphonse I. Lipetz on Transmission of Power on Oil-Engine Locomotives, presented at the Spring Meeting, San Francisco, Cal., June 28 to July 1, 1926, of The American Society of Mechanical Engineers. The paper appeared in MECHANICAL ENGINEERING in two installments in the issues of August and September, 1926.

C. A. NORMAN.[1] The paper is an extremely timely one. We have now in this country arrived at a thorough realization of the possibilities of the Diesel engine, both from the point of view of economy and from that of dependability. In the form of the Diesel-electric drive we have also shown our willingness to help in the work of adapting the Diesel engine to locomotive drive.

However, in reading the author's paper one cannot help but be impressed by the far greater versatility of development along this line that has taken place in Europe. It is surely not desirable that we, at this early stage of the development, should confine our attention entirely to the electric drive. It is admitted that this drive is heavy, costly, and yet not startlingly efficient. Mechanical transmissions—meaning thereby all non-electric transmissions—not only proposed, but actually tried out in Europe, show that there are many other ways of solving the problem. Some of these give greater simplicity, some give greater efficiency, and almost all give lower weight and less first cost than the Diesel-electric drive.

It is certainly not for want of engineering ability that we refuse to go into these things in this country. Many ideas along this line must have come to American engineers, besides the writer's own. The difficulty seems to be in encouraging commercial concerns to spend money in experimentation. In this respect the writer believes that we have something to learn from the Europeans. It is certain that no new invention arose perfect on the first day, and very often astonishing efficiency and dependability have been attained by detail perfection of machinery which at first looked unpromising. The Diesel engine itself is an outstanding example in this line.

It is sincerely to be hoped that American industrial enterprises will furnish the engineering talent of the country sufficient support so that we may not have to look to Europe with envy for what engineers over there are allowed to try out and develop. To refuse this support is a serious waste of one of the country's most valuable mental assets.

ELMER A. SPERRY.[2] This paper gives a very complete résumé of all the attempts to solve the difficult problem of producing a transmission involving all of the requirements of developing variable, including very high, torques from a prime mover having the universally recognized characteristic of developing measurably constant torque. The difficulty with all combustion engines is that when they are overloaded they stop, so that some method must be developed for preventing overloading and at the same time producing the heaviest torque at low speed, thus breaking away the load from its high journal friction coefficient of quiescence and also energizing the mass in the process of acceleration.

The paper shows the very great diversity of solutions that have been brought forward by the best minds in all industrial countries. The solution that has been most successful and has been adopted to the greatest extent in practice is of course the electrical. This has several definite disadvantages:

1 It is heavy

2 It is expensive

3 Overloading is disastrous, especially while developing high torques at low speed

4 It is sensitive, even to the point of being rendered inoperative by over-application of moisture or water

5 Its efficiency, while looked upon as commercially good, is in point of fact too low at both ends of the cycle—at low speeds and high torque and also at high speed—remembering that these losses are double; those of the generator plus the losses of the motor.

This is referred to in the first paragraph of Class B—Elastic Fluid Transmissions,[3] and we cannot but emphasize the statement that it is a pity to use a transmission all the time, especially after its real function of accelerating the load has been discharged. When this acceleration has been completed, practically 100 per cent of its usefulness has been realized. Then a straight-through connection should be substituted, where the losses are practically all eliminated, and the flexibility of the prime mover should be employed from that point on. This brings us to the realization that with the best service in locomotives we are bound to come to the same recognition of the value of the great feature in the automobile, namely, the prime mover of great flexibility. Another consideration is that the power developed as mechanical energy and finally utilized at the drawbar as pure mechanical energy should never be allowed to depart from the realm of mechanics. In other words, it should not be necessary to suffer all the losses consequent to transferring mechanical energy into electricity and then, on the spot, transferring it back from electrical to mechanical energy, entailing a second loss in addition to the first. Distant transmission of energy, of course, forms no part of this particular problem.

Hydraulics have been looked to as a possible means of confining the transmission to the realm of mechanics, but up to the present time this method has involved so much detail and so many expensive moving parts with their consequent wear and deterioration, at the same time operating at very low efficiencies, that while sufficient flexibility and trading of speed for torque are obtainable, the system has never reached that point where it would justify extensive and large-scale adoption. No better illustration could be asked than the ingenious Schneider transmission shown in the author's paper and discussed in Class B under the head of Differential Transmissions.

It is believed by the writer that this field of hydraulics has not yet been exhausted and whereas it has been proposed, as in the Föttinger transmission, to utilize turbo action in place of a multiplicity of plungers, pistons, cylinders, valves, etc., yet the Föttinger solution is looked upon as having characteristics not at all suiting the requirements, and as being too heavy, cumbersome, and lacking in efficiency.

For some time past a group of engineers have been engaged upon a simplification of the turbo transmission with a view to confining its action entirely to its proper sphere of usefulness, namely, that of acceleration, and have hit upon an extremely effective method of its automatic substitution for straight-through drive, eliminating practically all losses at all of the higher speeds. The interesting point has been observed in practical trials of this transmission that the change-over, which is automatically effected, may be brought in at any point desired, depending upon the load, grade, or desire of the engine driver; i.e., if his train is light or if the grade has changed he can instantly revert to straight-through connection by simple manipulation of his engine speed. Further interest centers in this new turbo method in that whenever the straight-through drive comes in, the turbo automatically ceases all functions and is completely eliminated from the system, always standing ready to be instantly called into action as occasion arises.

This new turbo drive falls under Class B of the paper, is strictly differential, and has been found to operate at high efficiency. Since it may be interesting to note just how it compares with the electric drive, the curves of Fig. 32 have been prepared. This is an example of a 750-hp. transmission. Curve A is taken from a paper by Mr. Katte, electrical engineer of the New York Central Railroad, sub-

[1] Professor, Machine Design, Ohio State University, Columbus, Ohio. Mem. A.S.M.E.

[2] President, Sperry Gyroscope Co., Brooklyn, N. Y. Mem. A.S.M.E.

[3] See MECHANICAL ENGINEERING, vol. 48, no. 9, Sept., 1926, p. 929.

mitted as a discussion at a joint meeting of the A.S.M.E. and the A.S.C.E. on February 18, 1926, and shows the electric transmission of a Diesel freight locomotive. The curve B shows an ideal curve with no losses. Interest centers on the curve C which is the curve of tractive effort due to the new turbo accelerator, trailing into the line D which is the straight-through gear connection. It will be seen that the line D is very much above the electric and the same is true of curve C, and whereas the point E is not quite as high as the peak of the electric curve, yet it has two paramount characteristics: (1) It holds on to the sustained tractive effort to a point six or eight times as far along in mileage as the electric; and (2) it will not burn up or destroy itself if run continuously at any of these high values, which is in the greatest possible contrast with the facts regarding the electric transmission in the starting zone. The

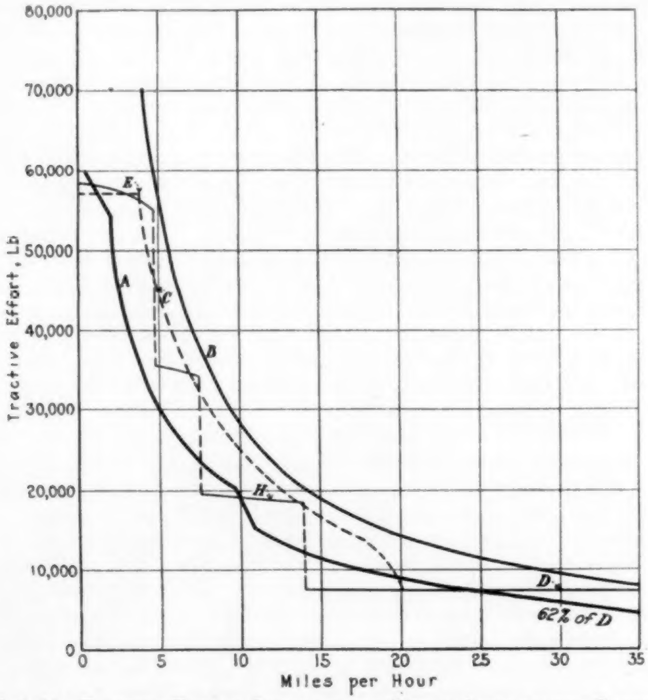

FIG. 32 TRACTIVE-EFFORT CURVE OF THE TURBO ACCELERATOR GEARED LOCOMOTIVE (750 HP.; 128 TON)

smooth and continuous power-speed curve given by the accelerator gives a higher efficiency than the electric, and compared with gears, the completeness with which it is sustained from one end to the other is in marked contrast to the frequent interruptions of the power in the gear transmission at the points where the old gear ratio is dispensed with and the new ratio is taken on. See line H, illustrating a four-speed transmission. One outstanding advantage of the accelerator cycle of operation is, as stated, that it gives a smooth and continuous transition from the point of highest development of torque to the lowest, in this way taking the place of three out of four gear changes, including the original clutching, and eliminating all but the last interruption, at each of which points it will be remembered there is an interval during which the power plant is completely divorced from the load. The single transition at the foot of the curve to the straight-through line D is comparable with the series-parallel change-over seen in the electric-transmission curve to the left, the accelerator reaching the straight-through connection at a point farther along on the speed curve than either the gear or the series-parallel part of the electric. Moreover, the transition point between the lower end of this curve and the line D does not involve as great a percentage of change as the corresponding point on the electric. Tests are being pushed rapidly on this transmission. The curves given herewith are based on test data and are looked upon both as interesting and promising.

R. EKSERGIAN.[4] Locomotive performance may be divided into two ranges (1) the adhesive range, wherein the tractive force is dependent upon the adhesion weight on the drivers, and (2) the horsepower range which depends upon the performance of a locomotive as a power plant. We are thus concerned in mechanically designing a mechanism that can transmit large torque loadings at low speeds and then proportioning a minimum-weight power plant to give the maximum tractive force at the higher speeds for a given axle as well as total weight of locomotive. The Diesel engine is in the nature of a constant-torque machine; i.e., the card area and mean effective pressure have fixed and constant maxima, so therefore it is evident that the transmission problem is paramount, and what we are principally concerned with is its (1) flexibility, (2) minimum weight, (3) reduction in first cost, and (4) maximum simplicity and ruggedness which go with minimum maintenance.

Directly connected with the transmission mechanism is the question of the type of drive which may be divided into (1) some form of direct axle drive, and (2) jackshaft side-rod drive. The former has certain advantages in flexibility in the arrangement of wheelbase, etc., and particularly qualifies the straight electric transmission. The side-rod drive offers certain advantages in weight reduction and compactness in wheelbase, etc., but, on the other hand, has some very definite limitations. It can be shown that with side-rod drive a change-over position occurs at the 45-degree angle with quadrant spacing of the cranks, but with unequal plays or lengths of rods of one side over the other, etc., the change-over may occur at smaller angles, with large loadings on the rods, jackshaft, and axles. This condition is more likely possible in the jackshaft drive, due to the necessity of smaller plays, than in steam-locomotive practice. Thus careful attention must be given to the design, with subsequent careful maintenance in the jackshaft drive for successful operation. Moreover, we come to a very fixed limitation in the adhesive capacity per jackshaft. In the ordinary proportions of wheel centers, it may be stated that 180,000 lb. adhesive load is the extreme limit of a single jackshaft drive, whereas comfortable proportions may be limited to 150,000 lb. Thus heavy switching service with over 240,000 adhesive capacity required would require two jackshafts and systems of transmission with corresponding weight increase, unless the jackshaft can be located between two wheelbases with corresponding spread of total rigid wheelbase.

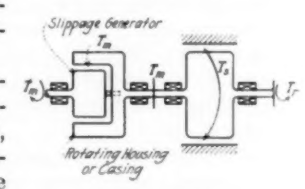

FIG. 33

The author has given a careful review of the various types of transmissions. In the writer's opinion, the differential elastic-fluid transmission offers the most interesting type for further expansion. The following simple analysis made some time ago may give a somewhat different aspect of the problem.

Referring to Fig. 33, if,

T_m = driving motor torque
T_s = torque due to auxiliary motor
T_r = resultant torque
w_m = speed of motor
w = speed of driven shaft

then, $T_r = T_m + T_s$ for the resultant torque.

That is, the motor torque is augmented by the secondary torque T_s due to the auxiliary motor and, due to the slippage of the generator $(w_m - w)$, the generator develops $T_m\ (w_m - w)$ ft-lb. per sec. and therefore the auxiliary motor torque, obtained from

$$E_h T_m\ (w_m - w) = T_s w$$

is

$$T_s = E_h T_m \left[\frac{w_m - w}{w_m}\right]$$

where E_h = efficiency of transmission.

Evidently as the drive shaft approaches the speed of the motor, T_s gradually reduces to zero, while at starting or very low speeds, $(w_m - w)$ is large and w small; therefore T_s, the secondary torque, becomes very large. This condition, of course, gives the ideal requirements for a perfect transmission.

Moreover, at any intermediate speed the efficiency with this arrangement is much higher than could be obtained by any direct system, thus:

If E is the overall efficiency, and E_m the overall mechanical efficiency of the system, then,

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$$E = \frac{[T_m w + E_h T_m (w_m - w)]\, E_m}{T_m w_m} = \left[\frac{(1 - E_h)\, w + E_h w_m}{w_m}\right] E_m$$

Therefore, assuming a hydraulic transmission efficiency at 0.75, the efficiencies will be as follows:

Efficiencies

	$w/w_m = 0$	$w/w_m = {}^1/_4$	$w/w_m = {}^1/_2$	$w/w_m = {}^3/_4$	$w/w_m = 1$
Slippage drive	$0.750\ E_m$	$0.813\ E_m$	$0.875\ E_m$	$0.938\ E_m$	$1.00\ E_m$
Direct transmission	$0.750\ E'_m$	$0.750\ E'_m$	$0.750\ E'_m$	$0.750'\ E_m$	$0.750\ E_m$

It is to be noted that the equation of efficiency reduces to

$$E = E_h E_m + (E_m - E_m E_h)\frac{w}{w_m}$$

which is exactly the same form as given by the author.

The Schneider hydraulic transmission is based essentially on this principle. The torque at the generator rotor or reciprocating clutch is

$$T_m = \frac{n_m p(\pi/4) d_m{}^2 S_m}{2\pi} \text{ ft-lb.}$$

and the torque extered on the secondary or auxiliary motor drive is

$$T_s = \frac{n_s p(\pi/4) d^2{}_s S_s}{2\pi} \text{ ft-lb.}$$

Where n, d, and s are the number, diameter, and stroke of cylinders, and p the oil pressure used. If r_m and r_s are the respective gear ratios to the jackshaft where the total torque is combined, having angular velocity w, the resultant torque is,

$$T_r = r_m T_m + r_s T_s$$

Due to the law of continuity of the fluid, we have also,

$$n_m(\pi/4) d_m{}^2 S_m\,(w_m - w/r_m) = n_s(\pi/4) d_s{}^2\, S_s\, 4/r_s$$

Therefore, as we should expect from first principles,

$$(w_m - w/r_m) T_m = T_s w/r_s$$

That is, the slippage energy is completely utilized, neglecting losses. The variation of speed and torque is effected by varying the stroke in the secondary.

A similar scheme was proposed by the writer some time ago in the form of an electromechanical transmission. Its only advantage over an electric drive would be in the reduction in weight. Two constructional difficulties, however, cannot be overlooked which are common to the Schneider type as well and they are, first, that the bevel-gear proportions limit the drive to around 500 hp., and second, that the rotating housing of the generator offers complications. With the introduction of two units, favorable also for the jackshaft drive, the following analysis is of interest.

The engine and rotor A of the magnetic clutch A-B are connected by the same shaft. (See Figs. 34 and 35). The revolving casing B is directly connected to bevel gear C which transmits motion to a bevel gear D. Bevel gear D is keyed to the auxiliary jackshaft H-H as well as to two spur gears E-E at either end of shaft. Spur gears E-E engage with the main gears G-G keyed to the jackshaft. An auxiliary motor M drives the main gears G-G through the motor pinions F-F.

The mode of operation is as follows:

(1) At starting or low speeds the engine torque is transmitted by the clutch and increased by the gear reduction $\left(\frac{G}{H} \times \frac{D}{C}\right)$ at the jackshaft. The slippage between A and B of the clutch generates electric power which is transmitted to the motor M. As the slippage is maximum, at low speeds, maximum torque is exerted on the auxiliary motor, and its torque is augmented at the jackshaft by the gear ratio G/F. The total torque at the jackshaft is, therefore, the sum of the engine torque increased by its gear ratio, and the motor torque increased by its gear ratio.

(2) At speed, little power is transmitted by relative slippage of AB, the greater part of the power being transmitted mechanically directly through the clutch to the jackshaft.

Obviously the gear ratio from the casing of the clutch to the jackshaft must be designed for increasing engine torque at the jackshaft, equal to the required torque at the jackshaft corresponding to the rated speed of the locomotive.

The following data, with Fig. 36, illustrate the calculation of proportions.

1000 hp. total, 500 hp. per unit
Wheel diameter = 57 in., stroke = 24 in.
Adhesion weight = 4 × 35,000 or 140,000 lb.
Maximum tractive force = 30,000 lb.

$$\text{Tractive force at 30 m.p.h.} = Z = \frac{375{,}000}{30} = 12{,}500 \text{ lb.}$$

$$\text{Ratio}\ \frac{\text{(maximum)}}{\text{(rated)}} = \frac{30{,}000}{12{,}500} = 2.4$$

At 30 m.p.h., clutch gear ratio is designed to transmit full engine torque. Hence the auxiliary motor at starting must be designed to transmit 2.4 to 1 or 1.4 rated engine torque.

$$\text{Jackshaft torque at 30 m.p.h.} = \frac{57}{2} \times \frac{12{,}500}{12} \text{ or } 29{,}700 \text{ ft-lb.}$$

$$\text{Engine torque at 1200 r.p.m.} = \frac{1000 \times 33{,}000}{2\pi\ 1200} \text{ or } 4370 \text{ ft-lb.}$$

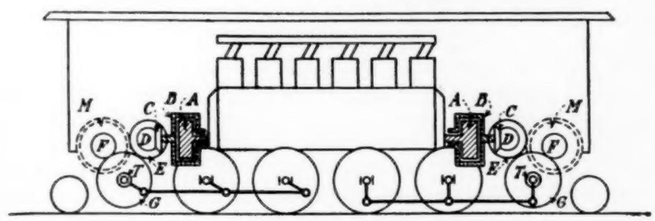

Fig. 34

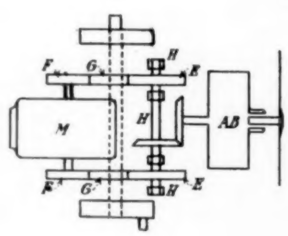

Fig. 35

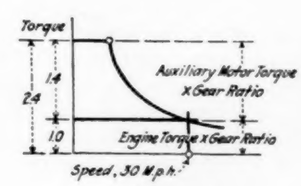

Fig. 36

$$\text{Hence the clutch gear ratio} = \frac{29{,}700}{4370} \text{ or } 6.80$$

$$\text{Tangential force bevel gear} = \frac{2185}{{}^1/_2} \text{ or } 4370 \text{ lb.}$$

Motor gear ratio:

Auxiliary motor speed at 30 m.p.h. = 1200 r.p.m.

$$\text{Driver speed at 30 m.p.h.} = \frac{30}{53} \times 336 \text{ or } 190 \text{ r.p.m.}$$

$$\text{Motor gear ratio} = \frac{1200}{190} \text{ or } 6.32$$

As to weights: Assume the weight of motor and generators to vary as the square root of the maximum torque (i.e., maximum current heating). That is, doubling the torque would increase the weight by 41 per cent and with 4 times the torque, the weight would be increased twice.

Then for 500 hp. direct electrical drive (noting the gear ratios would be about the same, i.e., between 6 and 7) we have a total weight of 2 units, i.e., assuming unity for weight corresponding to motor or generator. With this drive the torque transmitted electrically is $\frac{2.4 - 1}{2.4}$ (see tractive-force curve) or $\frac{1.4}{2.4}$ or approximately 58 per cent of the total torque. Hence the weight ratio of electrical apparatus is roughly

$$\frac{W \text{ electro mechanical}}{W \text{ direct electric}} = \frac{\sqrt{0.58}}{\sqrt{1}} \text{ or } 0.76$$

i.e., the weight of this electric drive is equivalent to 76 per cent of the weight of the electric drive. This ratio, however, would be somewhat increased by additional gearing and combining the generators into one unit.

William Elmer.[5] In comparing the merits of Diesel and steam locomotives, we as engineers ought to face the qualifications which a Diesel locomotive must possess.

We have now reached the point with steam locomotives where we can say that it is fruitless to expend time on the smaller units on which the German and other engineers have been working. So far as the writer knows a 1000-hp. unit is the largest of the actual Diesel constructions in existence, while steam locomotives of about 4000 hp. have been built. Therefore, we should work toward the design of locomotives, of the Diesel prime-mover type, which can compete with existing steam locomotives with a 4000-hp. unit as a minimum. If such a unit cannot be produced the field for the Diesel locomotive will be very limited. Existing locomotives are useful in switching service in cities where the use of steam locomotives has been prohibited by city ordinance but for heavy open-country traffic the writer believes 4000-hp. units must be attained or the Diesel locomotive cannot compete fully with the steam locomotive.

Further, we must face the fact that we need traffic powers in the vicinity of 200,000 lb. so that any devices for reducing the power of the engine into torque at low speeds must be of the order of 200,000 lb. at the rim of the driver.

In addition to that, we must face the fact of cost. Steam locomotives of approximately the capacity named can be bought for about 17 cents a pound, so that roughly $100,000 should be the cost of the unit to be designed. Some years ago the writer attempted to work out a design but could see no possibility of reaching the required capacity at a cost in any way competitive with the steam locomotive.

On the other hand we have the Diesel efficiencies which naturally are well worth striving for, but since modern steam locomotives are able to develop a horsepower-hour in the cylinders on about 16 lb. of steam and the efficiency of transmission is in the vicinity of 90 per cent, a serious problem is presented.

The question of availability for service should also be kept in mind. While the steam locomotive is available for service about fifty per cent of the time and the electric locomotive more than ninety per cent, we must realize that the Diesel electric may not be even as satisfactory as the steam locomotive, if the design is so complicated and the number of parts needing repair so great as to throw the engine out of service when it should be working on the road hauling trains.

Alphonse I. Lipetz.[6] If I should be permitted to reply to the remarks made during the discussion, in an order different from that in which they appeared, I would start with Elmer A. Sperry's contribution which supplements the paper by giving very interesting information on a transmission of the differential class. Mr. Sperry apparently does not yet see fit to give details of the actual design, and thus does not enable us to place the transmission in proper relation to other transmissions in the classification scheme which was followed in the paper, nor does he permit us to form a clear conception of its merits. However, so much can be inferred from his remarks—that the transmission is a combination of a turbo-drive with a purely mechanical transmission which at higher speeds automatically provides a straight-through drive from the prime mover to the driven shaft, the turbo-drive being entirely eliminated at these speeds. According to Mr. Sperry, the transmission is now undergoing tests, and the results are promising. It remains only to express our wish that the test results and the design should soon become known to the engineering profession.

It is very gratifying to see that Mr. Eksergian corroborates the correctness of my formulas and conclusions in reference to the differential elastic-fluid transmissions. The transmission of the differential electric type shown on Fig. 35 is essentially the Entz transmission with bevel and spur gearing used in the Schneider type. It may be called the electric analogy of the Schneider gear, or a "schneiderized" Entz transmission. But, whatever the classification characteristic may be, the electric features will probably render the transmission heavy and expensive. Mr. Eksergian's approximate calculation of weights takes into consideration only the motors and generators, but it is more than probable that the bevel and spur gears, the jackshaft, the additional bearings, especially the extension of locomotive frames required by the design of the transmission, the side-rod drive, etc., will offset the calculated 24 per cent saving in weight of the motors and generators.

The case, however, is different with the differential hydraulic transmission, as a hydraulic transmission is inherently light in design. A very detailed weight estimate made on the basis of a complete design of a 750-b.hp. locomotive with a differential hydraulic transmission showed a total saving of 30 per cent in weight as compared with a similar locomotive with full-power electric transmission. The differential hydraulic transmission itself weighed only about 50 per cent of the electric drive.

Mr. Elmer's remarks are very practical, but they are not exactly within the scope of the present paper which deals only with one side of the oil-engine locomotive problem, namely, with that of the transmission of power. The economic and railroad-operation aspect of the oil-engine locomotive will be discussed in a separate paper, but as the questions have here already been raised, I will reply to them briefly:

As regards availability, the experience so far with the 60-ton and 100-ton oil-electric switching locomotives have proved that they are available practically all the time. In reference to price—the interest on the investment is only one item in the expense sheet, and must be considered jointly with other operation expenses of which the fuel cost is the most important one; there are no indications that the maintenance cost of oil-engine locomotives will be higher than that of steam locomotives. With respect to power, there are two reasons to account for the fact that the power of the largest oil-engine locomotive in existence does not exceed 1000 hp.: first, that the oil-engine locomotive is just in the course of its experimental development, and it so happens that we discuss the question at the time when only 1000-hp. units have been built. But progress is going on; the Schneider-Still locomotive, described in the paper, which is now under construction at the Schneider & Co.'s plant in Creusot, France, will develop at full speed about 1800 hp. Locomotive builders in this country would also be ready to build oil-engine locomotives with electric transmission of 1500–2000 hp. if orders from the railroads were forthcoming. The second reason is that the 300–600-hp. switching locomotives seem to answer the purpose very well. The 4000 hp. of which we are apt to speak when we refer to the power of American locomotives is being developed only at high speeds, usually at 50–60 m.p.h., whereas at the ordinary speeds of switching service (6 to 10 m.p.h.) the more moderate power of 600 hp., possibly 1000 hp., is very near the limit which is required for this service.

The development of the oil-engine locomotive cannot be successful without the railroads' coöperation and assistance. The progress made in Europe is mainly due to the initiative of the railroads themselves. Professor Norman's opportune appeal to American industrial enterprises should be understood as referring to railroads as well.

Regular passenger air service between Egypt and India in connection with steamers from England to Egypt will be opened next January, it was announced in London on September 7. The service will be operated by the Imperial Airways, a British Company, and will be subsidized for the first five years by the British Government. The first aircraft to run on the new service are scheduled to fly from England to Egypt January 1 next, and the first regular flight from Egypt to Karachi, in India, is planned for January 12.

For three months thereafter there will be regular fortnightly planes between Egypt and Basra only, it being assumed that a certain time will be necessary to study and surmount the difficulties of the last lap between Basra and India. After preliminary organization of the route, in which the airship company and the British Government will coöperate, the final section from Basra to Karachi will be opened for commercial air service, making a total distance of 2500 miles to be regularly traversed by airplanes from Cairo to Karachi.

Fares by the new airplane service will be about $360 from Cairo to Karachi, about $200 from Cairo to Bagdad and about $250 from Cairo to Basra. This will not only cover the flight but also accommodation an tight (when flights will not be attempted) and meals throughout the journey. (*New York Times*, Sept. 8, 1926.)

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[6] Consulting Engineer, American Locomotive Company, Schenectady, N. Y. Mem. A.S.M.E.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Gas Radiation During Flow Through a Pipe

IN A PREVIOUS investigation entitled Heat Transmission in an Internal-Combustion Engine, (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 67, 1923, pp. 692, et seq.), the author, Prof. Wilhelm Nusselt, reported on his tests on the measurement of radiation from hot gases. In the present investigation he attempts to apply the values and formulas found previously to the case of radiation from gases of combustion in furnaces and boilers.

In the previous investigation the author found the radiation from a certain volume of gas to be

$$Q_1 = E_s A_1 F \text{ kg-cal. per hr.} \qquad [1]$$

where F is the surface area of the hot mass of gases in square meters, A_1 its absorption capacity, and E_s the black gas radiation per hour per square meter of area. The author has determined this black gas radiation for a mixture of equal volumes of carbon monoxide and carbon dioxide, and found it to be

$$E_s = 0.362 \left(\frac{T}{100}\right)^4 \text{ kg-cal. per sq. m. per hr.} \qquad [2]$$

Furthermore, he has shown that this value agrees well with values obtained in tests by Callendar and David, who measured respectively the radiation of the gases of combustion in a Bunsen burner and of the gases of combustion of various compositions in a bomb.

The absorption capacity of a mass of gas of volume V_0 has been previously found to be

$$A_1 = \frac{a}{\pi F} \times \int_F \int_{V_0} \frac{\cos\alpha\, e^{-ar}}{r^2}\, df\, dV \qquad [3]$$

In this equation a is the absorption coefficient of the gas, which Nusselt found to be

$$a = 15 \text{ m.}^{-1} \qquad [4]$$

while Callendar gives the value

$$a = 5.39 \text{ m.}^{-1} \qquad [4a]$$

David's tests indicated that a increases with the gas pressure and decreases with increase of gas temperature, and his values lie between 3.7 and 9.0. Reverting to Equation [3],

- dV is an element of the total volume V_0
- df is an element of the surface of the volume V_0
- r is the distance of the volume element dV from the surface element df, and
- α is the angle r makes with a line normal to the surface element df.

The author, Professor Nusselt, has determined the integral appearing in Equation [3] for the case of a sphere. For a sphere of radius r_0, he found that the following expression holds good:

$$A_1 = 1 - \frac{1}{2a^2r_0^2} + \frac{1 + 2ar_0}{2a^2r_0^2}\, e^{-2ar} \qquad [5]$$

The absorption capacity of a gas sphere therefore depends only on the factor $2ar_0$ and, as shown in Fig. 1 and Table 1, increases with the increase of this factor.

The author proceeds next to compute from Equation [3] the absorption capacity for a mass of gas of cylindrical shape, such as, for example, a volume of gas flowing through a pipe. In making this computation he assumes that the pipe is infinitely long, and because of this the formula ultimately obtained is practically correct only for a cylinder of great length as compared with its diameter. If we write Equation [3] in the form

$$A_1 = \frac{a}{\pi F}\int_F df \int_{V_0} \frac{\cos\alpha\, e^{-ar}}{r^2} dV \qquad [3a]$$

then in the case of an infinitely long cylinder the volume integral is the same for all surface elements, so that

$$A_1 = \frac{a}{\pi}\int_{V_0} \frac{\cos\alpha\, e^{-ar}}{r^2}\, dV \qquad [3b]$$

Let it be assumed next that the surface element df for which it is desired to compute the volume integral lies at point A, Fig. 2, on the surface of the cylinder. Spherical polar coördinates are selected for computing the space element dV so that use is made of the two angles φ and β and the distance r of the space element from point A. If a be any point in the cylinder with coördinates φ, β, and r, and if these be increased by an addition of the differentials $d\varphi$, $d\beta$, and dr, a space element is obtained with points a, b, c, d, e, f, g, and h. The magnitude of the volume element [The author uses indiscriminately the expressions "volume element" and "space element," and this practice is followed in the abstract—EDITOR] is then

$$dV = r^2 \cos\beta\, dr\, d\varphi\, d\beta \qquad [6]$$

Cos α in Equation [3b] can be easily expressed by angles φ and β. Through the corner point a of the space element is passed a plane parallel to the x-z plane. The angle is found in the plane passing through the normal to the surface element df in point A, hence through the y-axis and through the line connecting points A and a. It intersects the other plane along the straight line an. The triangle Aan thus obtained contains at A the angle α. Since at n it forms a right angle, the following holds good:

$$\overline{An} = r\cos\alpha \qquad [7]$$

and since the triangles Aal and Aln are also right-angled triangles,

$$\overline{An} = r\cos\beta\cos\varphi \qquad [7a]$$

By equating the right-hand members of these two equations the desired relation is obtained, namely,

$$\cos\alpha = \cos\beta\cos\varphi \qquad [7b]$$

If these values and those in Equation [6] be inserted in [3b] the following is obtained:

$$A_1 = \frac{a}{\pi}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\int_0^{l_0} \cos^2\beta\cos\varphi\, e^{-ar}\, dr\, d\beta\, d\varphi \qquad [3c]$$

The upper limit of integration for the distance r is the line $\overline{Ar} = l_0$. If the radius of the cylinder under consideration be r_0, it follows from the two right-angled triangles Apu and Arp that

$$l_0 = \frac{2r_0\cos\varphi}{\cos\beta} \qquad [8]$$

and further, since β and φ are independent of r, Equation [3c] may be integrated with respect to r, in which case the following is obtained:

$$A_1 = \frac{1}{\pi}\left\{\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} \cos^2\beta\cos\varphi\, d\beta\, d\varphi - \int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} e^{-\frac{2ar_0\cos\varphi}{\cos\beta}}\cos^2\beta\cos\varphi\, d\beta\, d\varphi\right\} \quad \text{[3d]}$$

or

$$A_1 = \frac{4}{\pi}\left\{\int_0^{\frac{\pi}{2}}\int_0^{\frac{\pi}{2}} \cos^2\beta\cos\varphi\, d\beta\, d\varphi - \int_0^{\frac{\pi}{2}}\int_0^{\frac{\pi}{2}} e^{-\frac{2ar_0\cos\varphi}{\cos\beta}}\cos^2\beta\cos\varphi\, d\beta\, d\varphi\right\} \quad \text{[3e]}$$

The first double integral is equal to $\frac{\pi}{4}$, from which it follows that

$$A_1 = 1 - \frac{4}{\pi}\int_0^{\frac{\pi}{2}}\int_0^{\frac{\pi}{2}} e^{-\frac{2ar_0\cos\varphi}{\cos\varphi}}\cos^2\beta\cos\varphi\, d\beta\, d\varphi \quad \text{[3f]}$$

The second double integral must be approximately calculated as a function of the parameter $2ar_0$. The functional relation thus obtained is shown in Fig. 1 and Table 1.

By using Fig. 1 or the table it becomes possible to compute the absorption capacity A_1 of a gas column for a given diameter of pipe. If, further, A_2 be the absorption capacity of the inner surface of the pipe wall, T the gas temperature, and T_w the wall temperature, then, as has been shown in the investigation cited at the beginning of this abstract, the coefficient of heat transfer for the radiation in the pipe is

$$\alpha_s = \frac{0.362}{\frac{1}{A_1} + \frac{1}{A_2} - 1} \times \frac{\left(\frac{T}{100}\right)^4 - \left(\frac{T_w}{100}\right)^4}{T - T_w} \text{ kg-cal. per sq. m. per hr. per deg. cent.} \quad \text{[9]}$$

Example. As an example of the application of the above theory the author uses tests on the heat transmission in a locomotive boiler made by Hilliger and published in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 60, 1916, pp. 877, et seq. The tubes of this boiler were 1.728 m. (68 in.) long and had an inside diameter of 0.045 m. (1.77 in.). Hilliger measured for various loads on the boiler the temperature of the gases of combustion at the inlet to and exit from the boiler tube and thereby determined the average coefficient of heat transmission α in the tube.

The author uses the above-given formulas to determine the part played by the gas radiation in determining the coefficients of heat transmission found by measurement. To do this he takes one of the Hilliger tests in which the coefficient of heat transmission was minimum, and hence the part played by the gas radiation should have been a maximum. The amount of heat flowing was $K = 13.2$, hence the coefficient of heat transmission was $\alpha = 13.3$. The velocity of flow of gas in the tube was 5.62 m. (22.3 ft.) per sec.

In deriving Equation [1], an assumption was made to the effect that the temperature of the radiating gas mass was the same at all points. This is not so in the case of a tube. In the present instance, for example, the temperature of gases at the entrance to the tube was 795 deg. cent., and at the end, 386 deg. cent. (1463 and 726 deg. fahr.). Also Equation [3] and Table 1 assume that the tube is very long and because of this a compromise must be sought for in applying the above formula to the case of radiation in a boiler tube. To do this the author divides the tube into three sections, each 0.576 m. long (22.7 in.), and believes that with this he satisfies sufficiently well the conditions necessary for the application of his formula.

If the actual temperature values along the tube axis are repre-

TABLE 1 ABSORPTION CAPACITIES A_1

$2ar_0$	Cylinder	Sphere	$2ar_0$	Cylinder	Sphere
0	0.0000	0.0000	3.50	0.9293	0.8547
0.10	0.0932	0.0642	4.00	0.9460	0.8865
0.20	0.1767	0.1243	4.50	0.9580	0.9073
0.25	0.2149	0.1520	5.00	0.9665	0.9232
0.30	0.2512	0.1792	5.50	0.9728	0.9356
0.40	0.3170	0.2308	6.00	0.9776	0.9454
0.50	0.3764	0.2748	6.50	0.9814	0.9532
0.75	0.5000	0.3835	7.00	0.9843	0.9595
1.00	0.5957	0.4715	7.50	0.9868	0.9646
1.25	0.6709	0.5451	8.00	0.9885	0.9688
1.50	0.7298	0.6066	8.50	0.9901	0.9724
1.75	0.7769	0.6596	9.00	0.9913	0.9753
2.00	0.8142	0.7030	9.50	0.9927	0.9778
2.50	0.8689	0.7719	10.00	0.9940	0.9800
3.00	0.9048	0.8220	∞	1.0000	1.0000

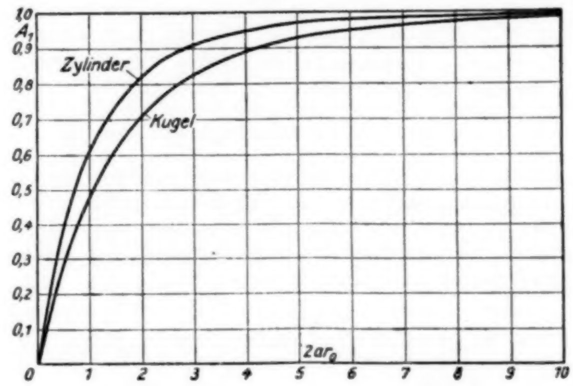


FIG. 1 ABSORPTION CAPACITIES ON A SPHERE AND A CYLINDER
(*Zylinder* = cylinder; *kugel* = sphere.)

sented approximately by an exponential function, there will be obtained, as applying to the ends of the respective sections of the tube, the gas temperatures from t_1 to t_4 given in Table 2, or in absolute units, the temperatures from T_1 to T_4.

The next problem is to calculate what will be the average gas

TABLE 2 GAS TEMPERATURES IN SECTIONS OF BOILER TUBES

Deg. cent.	Deg. abs.	Deg. abs., T_m	α_s kg. cal. per sq. m. per hr. per deg. cent.
t_1 = 795	T_1 = 1068		
		976	2.0
t_2 = 612	T_2 = 885		
		819	1.3
t_3 = 480	T_3 = 753		
		706	0.9
t_4 = 386	T_4 = 659		

temperature in each tube section. If it be assumed that in such a tube section there is an approximately linear temperature variation in the axial direction, it becomes possible to compute for the gas radiation of a tube section of length l, the average gas temperature from

$$T^4_m l = \int_0^l T^4 dx \quad \text{[10]}$$

which gives

$$T^4_m = \frac{1}{5}\frac{T_1^5 - T_2^5}{T_1 - T_2} \quad \text{[11]}$$

provided T_1 and T_2 are the gas temperatures at the beginning and end of a tube section. For purposes of calculation it is advisable to divide the temperatures by 100, which gives

$$T_m = 66.8\sqrt[4]{\frac{\left(\frac{T_1}{100}\right)^5 - \left(\frac{T_2}{100}\right)^5}{\frac{T_1}{100} - \frac{T_2}{100}}} \quad \text{[11b]}$$

This calculation shows that T_m may be expressed with sufficient precision by the formula

$$T_m = \frac{T_1 + T_2}{2} \quad \text{[12]}$$

The absorption capacity of the inside surface of a boiler tube is $A_2 = 0.96$. If we use as a coefficient of absorption of gases of combustion $a = 10\ m.^{-1}$, then $2\ ar_0 = 0.45$, and hence, in accordance with Table 1, the absorption capacity of the gases of combustion in the tube becomes $A_2 = 0.346$. This is the last of the magnitudes necessary in order to compute from Equation [9] the coefficients of heat transmission for the gas radiation in the three sections of the tube. The wall temperature during the tests was 150 deg. cent. (302 deg. fahr.).

If one compares the coefficients of radiation obtained in this way and given in Table 2 (which for the entire tube are 1.4 kg-cal. per sq. m. per hr. per deg. cent. difference), it will appear that 10 per cent of the heat transmitted in a boiler tube is due to gas radiation and the other 90 per cent to heat transfer by conduction.

Hilliger in his tests with flue gases increased the velocity of flow of gas to 21.4 m. (70.20 ft.) per sec., which increased the coefficient of heat transfer to 37.4 kg-cal. per sq. m. per hr. per deg. cent. difference. In such a case the average coefficient of heat transmission for the gas radiation would be $\alpha_s = 2.5$, so that 6.7 per cent of the total heat transmitted would be the share of gas radiation.

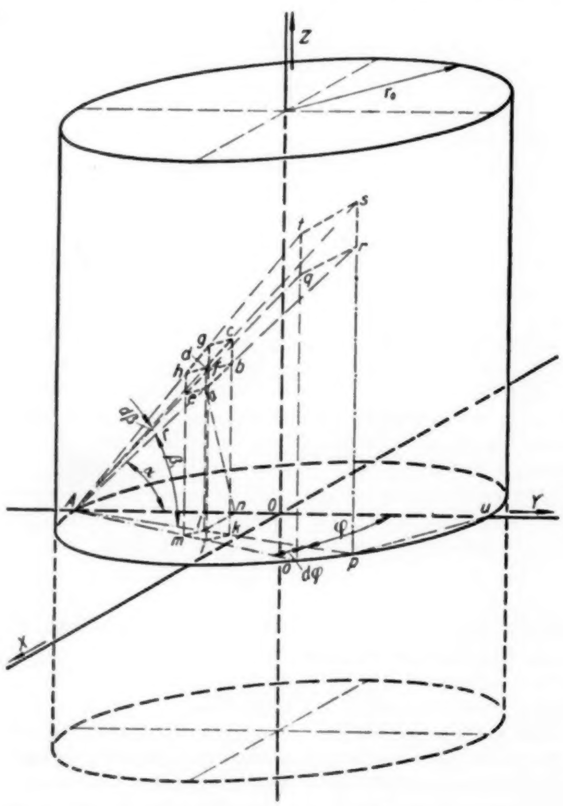


FIG. 2 SPACE ELEMENT IN A GAS COLUMN

From the above it would appear that while gas radiation in boiler tube is a factor, not more than 10 per cent of the total heat can be transmitted thereby. Gas radiation may play a more important part in heat transfer in a fire tube. For such a case, because of the comparatively small length of tube in comparison with the diameter d, Equation [3b] and Table 1 apply only approximately. If, however, it be assumed that $d = 1$ m. (39.37 in.), and as above $a = 10$ m.$^{-1}$, then Table 1 will give for the absorption capacity of flue gases in a flue tube $A_1 = 0.994$. A sphere of the same diameter as the flue tube has, according to Table 1, an absorption capacity $A = 0.98$, and the actual value may lie between the two, so that the author assumes $A_1 = 0.99$. The absorption capacity of boiler plate is 0.96. He assumes that the tube is a corrugated one with corrugations 0.2 m. (7.87 in.) apart, and that these latter increase the absorption capacity of the fire tube, so that he gives to A_2 a value of 0.97. The temperature of the gases of combustion at the entrance to the fire tube may be 1100 deg. cent. (2012 deg. fahr.), while the exit temperature is 500 deg. cent. (932 deg. fahr.) and the wall temperature 200 deg. cent. (392 deg. fahr.). In such a case the coefficient of heat transmission for gas radiation in a fire tube will be, according to Equation [9],

$$\alpha_s = \frac{0.362}{\frac{1}{0.99} + \frac{1}{0.97} - 1} \times \frac{10.73^4 - 4.73^4}{600} = 7.4 \text{ kg-cal. per sq. m. per hr., per deg. cent.}$$

There are no tests on the heat transfer by conduction in fire tubes, and the author derives for approximate use a formula from tests which he and Jürges carried out on the cooling of a vertical flat wall by a stream of air. With the surface rough the following was found:

$$\alpha_b = 6.47 w^{0.78} + 5.03\, e^{-0.6w} \ldots\ldots\ldots\ldots [13]$$

The length of the wall was in this case 0.5 m. (1.64 ft.) and its temperature 50 deg. cent. (122 deg. fahr.). The air blast had a temperature of 20 deg. cent. (68 deg. fahr.) and a pressure of 1.02 atmos. By applying relations derived from considerations of similarity the author derives the following general relations to cover the coefficient of heat transmission by conduction in a fire tube:

$$\alpha_b = 0.069 \frac{\lambda_m}{L} \left(\frac{wC_{pm}L}{\lambda_m}\right)^{0.78} + 0.76 \frac{\lambda_m}{D} \sqrt[4]{\frac{D^3 \gamma m^2 (T - T_w)}{g \eta m^2 T_m}}\, e^{-0.000{,}028 \frac{wC_{pm}L}{\lambda_m}} \ldots [13a]$$

Here D is the diameter of the fire tube. L is the length of one section of a tube made of smooth sheet, or in the case of a corrugated tube the length of one corrugation. Equation [13a] gives for the above example $\alpha_b = 13.9$, and hence the entire coefficient of heat transmission

$$\alpha = \alpha_s + \alpha_b = 7.4 + 13.9 = 21.3 \text{ kg-cal. per sq. m., per hr., per deg. cent.}$$

In accordance with this in a fire tube 28.8 per cent of heat is transmitted by gas radiation and 71.2 per cent by heat conduction. To this should be added also the share of radiation from the glowing fuel bed on the grate. This latter can be easily computed by using Lambert's law. If C_0 is the coefficient of total radiation of the glowing coal, which may be taken as 4.91 kg-cal. per sq. m. per hr. per deg. cent.[4] (i.e., the fourth power of temperature in degrees centigrade), then the intensity of radiation from coal is $J = \frac{C_0}{\pi}$. Not all of this radiation, however, reaches the boiler plate as a part $\frac{0.362}{\pi} \times e^{-ar}$ is absorbed by the hot gases of combustion. In this expression 0.362 represents the coefficient of radiation of black gas radiation, a the coefficient of absorption of gases of combustion, and r the distance of a surface element df_2 of the fire tube from a surface element df_1 of the glowing coal bed. In accordance with this the amount of heat radiated from a surface element of the coal bed per hour to a surface element of the fire tube is

$$d^2Q = \frac{4.91 - 0.362\, e^{-ar}}{\pi} \left(\frac{T_1}{100}\right)^4 \frac{\cos\varphi_1 \cos\varphi_2}{r^2}\, df_1 df_2 \ldots [14]$$

In this connection T_1 is the temperature of the coal bed; φ_1 and φ_2 are the angles made by the lines connecting the surface elements with the normals to these surface elements. Further details of this heat exchange through radiation from the coal bed are too dependent on the arrangement of the grate and firebrick in the fire tube to permit a general treatment. (Prof. Wilhelm Nusselt, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 70, no. 23, June 5, 1926, pp. 763–765, 2 figs., *tA*)

Centrifugal force can be very simply expressed in metric units as follows:

$$C = \frac{G R N^2}{900}$$

where C is the centrifugal force acting on a spinning body, in kg.; G, the weight of the body in kg.; R, distance of body from the axis of rotation in meters; N, r.p.m.

Short Abstracts of the Month

AERONAUTICS

Airplane and Engine Life

News has reached England that Alan Cobham completed his flight from London to Melbourne, covering some 10,000 miles in approximately five weeks and flying on an average from 400 to 600 miles each flying day. The chief interest in the flight from an engineering point of view lies in the fact that Cobham used the D.H.-50 plane which has already been to Rangoon and back and to Cape Town and back, and the same Jaguar engine which was used in the London-Cape-London flight. This would indicate that the DeHaviland plywood-covered fuselage with normal fabric-covered wing type of construction is able to withstand extremes of climatic conditions. (Editorial in *Flight*, vol. 18, no. 33/921, Aug. 19, 1926, pp. 503–504, *g*)

Interaction Between Air Propellers and Airplane Structures

This investigation was conducted at the Leland Stanford Junior University by the National Advisory Committee for Aeronautics at the request of, and with funds provided by, the Army Air Service.

The purpose of the investigation, the results of which are presented in this report, was the determination of the character and amount of interaction between air propellers as usually mounted on airplanes and the adjacent parts of the airplane structure—or, more specifically, those parts of the airplane structure within the wash of the propeller, and capable of producing any significant effect on propeller performance.

In Report 177 by Messrs. Lesley and Woods, such interaction between air propellers and certain simple geometrical forms was made the subject of investigation and report. The present investigation aims to carry this general study one stage further by substituting actual airplane structures for the simple geometrical forms.

From the point of view of the present investigation, the airplane structures, viewed as an obstruction in the wake of the propeller, must also be viewed as a necessary part of the airplane and not as an appendage which might be installed or removed at will.

The author comes to the conclusion that it is desirable to avoid such form and disposition of structure as will involve any extreme degree of interference (as shown by two of the models tested) or, if such designs are imposed, then a special effort should be made to increase to the maximum practicable limit the clearance between the propeller and the nearer parts of the structure. (W. F. Durand (Mem. A.S.M.E.), *National Advisory Committee for Aeronautics*, Report no. 235, 1926, pp. 3–23, 36 figs., numerous tables, *eA*)

Ryan Monoplane with Demountable Engine

In this engine the entire nose including the engine is demountable, making it possible to change motors in 20 minutes and eliminating the necessity of a large number of reserve planes for operating companies.

Among the other interesting features, the wing mounting may be mentioned. Heretofore in monoplanes not of the parasol or low-wing type it has been necessary to place a pilot's cockpit in the nose of the plane in order that good visibility might be obtained. In the *M*-1, as this machine is designated, the wing is attached directly to the structural part of the fuselage, but the cowling below the wings has been cut out in such a manner that good visibility is obtained on all sides. The wing is of the semi-thick type externally braced. The wing struts are steel tubes stream-lined to air-foil section. The wing and aileron designs have been so carried out that the ailerons will be operative after the stalling point has been reached. In case of a stall it is stated the plane does not go into a spin or nose dive, but settles slowly toward the ground. The gliding angle is approximately ten to one.

The planes are now in regular operation on the Pacific Coast and according to reports no trouble has been experienced with them. The ship has a speed range of from 45 to 135 m.p.h. when equipped with a Wright Whirlwind engine. With this engine its cruising speed is about 115 m.p.h., at which speed the plane has a fuel rate of 10 miles per gallon. The initial climb of 1200 ft. per min., and the landing characteristics mentioned above, enable it to be used on routes where small fields are the rule rather than the exception. Its price is $8400 with a Wright Whirlwind engine, or $2890 with a Super Rhone or Curtis OX-5, which puts it well within the range of the average concern desirous of entering the air-transport field. (Athel F. Denham, *Automotive Industries*, vol. 55, no. 5, July 29, 1926, pp. 174–175, 2 figs., *d*)

AIR MACHINERY

Windmill Tests

Although windmills have been in use for more than a thousand years, accurate data as to their efficiency cannot easily be obtained. The Institute of Agricultural Engineering of the University of Oxford has therefore made a useful contribution to our knowledge of the subject by publishing a report on the use of windmills, more especially for the generation of electricity. A windmill experimental station was erected on the Annables estate, midway between Harpenden and Luton. The field slopes southwestward toward the Dunstable road, and seven windmill plants of various types have been erected on it. The site is a good one, as it obtains the benefit of unrestricted winds from all directions. Full results of the economic, technical, and meteorological observations extending over a period of one year are given. The cost per electric unit utilized varied between 12.7 pence and 4.0 pence. By using improved wheels the cost of production for the smaller and more inefficient mills could be reduced by 30 or 40 per cent. Considering the very small dynamos used, having an output of only a few horsepower, these results are quite satisfactory. Some of the plants begin to operate when the wind attains a velocity of about 6 m.p.h. and cease operating when the velocity falls to 5 m.p.h. The results prove that in districts remote from a public electric supply small windmill power schemes might prove useful and economical. Those who already own an engine-generating set and desire to supersede or supplement it should consider adopting wind power. It is also to be remembered that on higher sites than Harpenden or in districts nearer the coast better results would probably be obtained. In Denmark and Germany considerable use is made of wind power in generating electricity. (*Nature*, vol. 118, no. 2962, Aug. 7, 1926, p. 203, *e*)

ENGINEERING MATERIALS (See Machine Parts: Irons for Piston Rings)

Hard Surface Steel

A new free-cutting steel of open-hearth quality adapted for case hardening and for forging where machinability is important now is being processed by the Jones & Laughlin Steel Corp., Pittsburgh. One of the properties of the new metal is that it develops a tough ductile core and a hard wear-resisting, normal case, free from soft spots, thus being adapted for case-carburized parts subject to severe abrasive wear, high stresses, and repeated shocks. Other uses include machined, case-hardened or heat-treated parts for automobiles, motorcycles, sewing machines, typewriters, adding machines, textile machinery, shoe machinery, and railroad and electrical work. The steel is furnished in hot-rolled or cold-finished bars. It will withstand cold heading. (*Iron Trade Review*, vol. 79, no. 9, Aug. 26, 1926, p. 499, and *The Iron Age*, vol. 118, no. 9, Aug. 26, 1926, p. 546, *g*)

The World's Mercury

A report on the mercury situation of the world has just been issued by the U. S. Bureau of Standards (compiled by J. W. Furness and R. M. Santmyers).

The United States production reached its peak of 79,000 flasks in 1877, and since that date, in spite of the assistance given by import duties and high prices, has steadily decreased. The estimated production in 1925 was around 9000 flasks.

The Spanish mercury ore is the richest, having for many years averaged over 6 per cent recoverable mercury; the United States

ore is the leanest, with 0.43 per cent, while that from the Italian districts yields around 0.7 per cent. Methods of mining and reduction have been highly efficient in the United States and Italy; they are crude and wasteful in Spain, yet owing to the high grade of the ore, the cost of Spanish mercury is the least. It was estimated in 1918 that in the United States costs were around $60 to $70 per flask, and in Spain, from $10 to $25. High prices for the metal seem inevitable with the expanding industrial uses. The average market price of mercury in this country in 1925 was $83 per flask, and the import duty under the 1922 schedule was 25 cents per lb. or $18.75 per flask. Hitherto there seems to have been no artificial control of prices, although since 1919 Spain and Italy have had the power to do so. (Compare editorial in *Engineering and Mining Journal*, vol. 122, no. 1, July 3, 1926, p. 1, *g*)

FUELS AND FIRING

Oil-Shale Extraction

A consideration of the factors affecting oil-shale mining and an analysis of the processes which may be employed for this purpose. While the paper deals exclusively with the mining of oil shale, it is of interest to mechanical engineers because of the general importance of the problem of utilization of the oil-shale resources of the country. The author rejects, at least in as far as mining in Colorado is concerned, the open-cut underground system for oil shale as well as resort to coal-mining methods. He thinks, however, that caving methods may be applied, such as the Alaska-Juneau. In this method the cost is 22.67 cents per ton, assuming the very high explosive factor of 18 tons broken per pound of powder. Whether, however, this process can be applied to oil shale is still questionable. There is, for example, the problem of the combustibility of oil shale from large blasts with standard explosives, as well as the danger of dust explosions in the passageways; next comes the danger in the case of bedded deposits of a tough material like shale, of having immense blocks of shale drop into the stope practically unbroken.

With temperatures around 5400 deg. fahr. at the point of explosion, a special "permissible" explosive will be required to prevent igniting of rich shale. Some shale will catch fire from a match and burn readily. By the use of Cordeau-Bickford fuse the danger of ignition from burning fuse is eliminated, but research would have to be made into the subject of explosives for this work.

New methods would probably have to be worked out and the author mentions the possibility of Alaska-Juneau practice with horizontal holes or holes of any desirable inclination of angle, holes of large diameter similar to those used in certain methods of quarry blasting. Even at that, however, certain problems will arise, among which may be mentioned the various matters connected with the auger bit, auger rods, etc. In this connection the following interesting remarks are made.

If an auger bit is made of the proper steel and is properly heat treated, it will cut any oil shale. This is based on the fact that hand augers are used to drill holes in fairly hard augite-porphyry in the oxidized zone. Most mining companies are not familiar with the possibilities of the auger. Such speeds as 17,000 ft. of hole in iron ore, by two miners, per month, make one realize that high speeds are obtainable if conditions are right.

The question of the best steel for auger bits has never been thoroughly investigated. The author has used hand augers in oxidized augite-porphyry, which was moderately soft drilling ground for hammer work, and drove a tunnel 300 ft. with them. The auger that gave the best service was made from an old file, picked up on an old mine dump on the Mother Lode of California and probably thirty years or more old. It was therefore made of Swedish steel, very pure, and had a high carbon content. The other augers on hand were made from either wagon springs of fairly low-carbon steel or else from American-made files, of quality inferior to that of the first one mentioned. The author drove over 2000 ft. of hole with the first auger, and in other work in a shaft drove it 1200 ft. That auger had therefore done over 3000 ft. of boring. On coming to the Missouri School of Mines, the author cut off the end of this auger and sent it to the Bureau of Mines at Minneapolis. There they analyzed the steel and found it to be a very pure 1.2 per cent carbon steel. The structure resembled the famous Damascus steel, in that it was formed of spherulitic cementite, with radial structure, in troostite. In this it resembles Damascus steel, except that the latter is 1.5 per cent carbon. The purity of the high-carbon steel and the heat treatment that the author always gave it on sharpening it was the reason for its superiority over the other augers.

Judging by the author's analysis, the question of mining oil shale still requires a considerable amount of development, and the author, for example, suggests a method of mining with inclined uppers, using deep-hole machines, so that no men work under the roof of the stope. Such a method would be a "longwall-shrinkage" method, as the shale would be drawn from the stope just as the ore is drawn from shrinkage stopes, but ore would be left up to the roof or back of the stope to support the excavation until the final breaking of shale in the stope could be finished. Then the whole stope filled with broken shale could be drawn. The roof of a rough flexible shale would rest on the broken shale in the stope, preventing large blocks dropping from the roof, which would happen if the shale were drawn too soon. The mechanical appliances would be the same as for shrinkage caving, and the holes would be drilled upward at a steep angle from a mining floor at the top of the ore chutes, and men and machines would always be under protection of roofs of narrow drifts or cross-cuts. The loading of these deep holes would be the principal problem, not drilling of the holes or the mining method.

Should there be no danger of fire in stopes, there seems to be little doubt that, as far as mining goes, the oil-shale deposits may be worked at costs below 60 cents per ton, this cost to include all overhead, with amortization, depreciation, insurance, and taxes. The retort problem and the question of the disposal of spent shale from the retorts are much more serious than those connected with the mining. (T. M. Bains, Asst. Prof. of Mining, Colorado School of Mines, Golden, Colo., in *Engineering and Mining Journal-Press*, vol. 121, no. 25, June 19, 1926, pp. 1009–1013, illustrated, *gp*)

In this connection the investigation of the Bureau of Mines as to the explosibility of oil-shale dust may be of interest. The conclusion at which the authors arrive is that the oil-shale dusts which were tested are explosive, and that their explosiveness increases with their combustible content. The formation of dust during the mining and handling of oil shale is almost unavoidable, and the same precautions against dust explosions should be taken in the industries producing or working with oil shale as are taken in safely operated coal mines. (Explosibility of Oil-Shale Dust, by V. C. Allison and A. D. Bauer, in *Reports of Investigations of the Bureau of Mines*, Serial no. 2758, June, 1926, 8 pp.)

Specific Heats of Petroleum Oils

The specific heats of fifteen petroleum oils have been determined over temperature intervals varying from 50 to 430 deg. fahr. The results may be expressed by the equation

$$C = \frac{(t + 670)\ (2.10 - \text{sp. gr.})}{2030}$$

where C = the specific heat
t = the temperature in deg. fahr.
and sp. gr. = the specific gravity of the oil at 60 deg. fahr.

The equation fits the data with an average deviation of 2.3 per cent at 240 deg. fahr., and represents oils whose specific gravity at 60 deg. fahr. varied from 0.75 to 1.00.

This equation, representing the variation of specific heat with temperature and with specific gravity, agrees reasonably well with the average of other specific-heat data available in the literature both at 60 deg. fahr. and at higher temperatures.

The equation applies, however, only to specific heats of oils in the liquid state and should not be used for solid oils or for vapors. The present data were all obtained at temperatures below boiling point of the sample and hence should not be applied to temperatures approaching the critical temperatures of the oils in fact for temperatures within 100 deg. fahr. of the critical point. (A. R. Fortsch and W. G. Whitman. Paper read before the Division of Petroleum Chemistry at the meeting of the American Chemical Society, Tulsa, Okla., Apr. 5–9, 1926. Abstracted through *Industrial and Engineering Chemistry*, vol. 18, no. 8, August, 1926, pp. 795–800, 7 figs., numerous tables, *e*)

The Development of Atomization Methods for Oil Burners

To DESIGN an oil burner that will produce the shortest possible flame, the most practical method seems to be not only to atomize the oil as finely as possible, but to discharge it into the furnace in the form of a whirling spray and discharge the air into the oil in such a manner that the air whirls in an opposite direction to the spray of oil, or is "blasted" into the fine drops of oil.

This was applied many years ago in an installation of oil burners to one of the first successfully oil-fired vessels in the United States Navy. About ten years ago a combustion engineer on the Pacific Coast rediscovered the same method of burning oil, but used an entirely different method of application.

As shown in Fig. 1, a cup-shaped casting is rigidly attached to the end of the hollow extended shaft of an electric motor or steam turbine. A large-diameter stationary oil tube passes through this hollow shaft and pours the oil in a small stream on to the inside surface of the cup. As the cup revolves at a speed of about 3600 r.p.m. the oil is thrown by centrifugal force from its rim in the form of a very fine spray or mist and whirled in a clockwise direction. The air necessary for combustion is furnished by a fan blower mounted on the hollow shaft just behind the nozzle. This air is

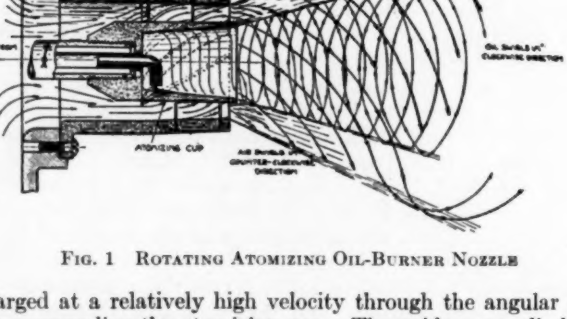


FIG. 1 ROTATING ATOMIZING OIL-BURNER NOZZLE

discharged at a relatively high velocity through the angular vane nozzle surrounding the atomizing cup. The guide vanes discharge the air in a counterclockwise direction into the already finely divided spray of oil, resulting in rapid mixing of oil and air and quickly completed combustion, which produces a very short, intensely hot flame.

Experiments with this burner have shown that in burning a definite quantity of oil per hour the flame is about one-third the length of the flame produced when the air guide vanes are removed from the nozzle and the oil and air both whirl in the same direction. It has also been found that with the vanes set at an angle of 55 deg. the flame is much shorter and wider than with a nozzle having vanes set at an angle of 70 deg. Thus the flame may be adapted to any shape of firebox, whether long and narrow or short and wide.

Burners of this type were installed abroad the U. S. Navy Yard tug *Navigator* at the Mare Island Navy Yard, California, and tests were made. In these tests the oil used was of about 14 to 16 deg. A.P.I. gravity and contained much foreign matter. It was not heated at all and was delivered to the burners under a pressure of only 25 lb., and gave apparently excellent results. Further tests are now being conducted at the Fuel Oil Testing Plant at the Philadelphia Navy Yard. During these tests it was found that a large percentage of water emulsified with the oil failed to extinguish the flame or interfere with the operation of the burner in any way. It is the writer's belief that this is due to the centrifugal force of the revolving cup automatically separating the water and the oil, due to their different specific gravities, right at the tip of the burners.

Another interesting and successful method of atomizing oil, used for years in industrial operations, has been adopted by a number of designers of domestic burners. In this method the oil is given a whirling motion by guide vanes and discharged at relatively high pressure through a very small orifice in the tip of the burner. This produces a very fine, cone-shaped spray. The air is then discharged into this spray of oil. In some cases guide vanes cause the air to whirl in the opposite direction to the path of the oil, while in other cases no guide vanes are used.

One manufacturer discharges the oil in a flat whirling sheet with a countercurrent of air whirled in the opposite direction by guide vanes set in the burner nozzle, and another designer has combined the use of the mechanical spray with a blast of preheated air. (One of a series of articles by S. D. Rickard in the *Heating and Ventilating Magazine*, vol. 23, no. 6, June, 1926, pp. 76 to 78, 8 figs. of which three are in this article, *dg*)

Anti-Knock Motor Fuels from Shale Oils

ANALYSES of fuels obtained by cracking shale oils check quite closely with the results obtained by motor tests on synthetic mixtures of straight-run gasoline and commercial benzol. For example, a straight-run gasoline from Cushing crude oil having an aromatic hydrocarbon equivalent of 11 per cent in admixture with 22.5 per cent of commercial benzol (total aromatic hydrocarbon equivalent 30.4) is the motor equivalent of the cracked gasoline from Green River shale oil. The original article contains (Table 3) analyses of cracked gasolines with corresponding Ricardo compression ratios. (Jacque C. Morrell and Gustav Egloff, Research Laboratories of the Universal Oil Products Co., Chicago, Ill. Paper under the title, Cracking of Shale Oil and Types of Motor Fuel Obtained Therefrom, before the Division of Petroleum Chemistry at the meeting of the American Chemical Society, Tulsa, Okla., Apr. 5–9, 1926. Abstracted through *Industrial and Engineering Chemistry*, vol. 18, no. 8, Aug., 1926, pp. 801–802, *e*)

New Fischer Process

AN ANNOUNCEMENT has recently been made in Germany that Dr. Franz Fischer has succeeded by a catalytic process in converting water gas into a mixture of liquid and solid paraffin hydrocarbons which strongly resembles Pennsylvania petroleum. The importance of this discovery lies in the fact that not only the first member of the paraffin series but also the higher members can be produced, and that the product may be made to consist chiefly of the higher boiling paraffins by a suitable choice of conditions. As an example of the possibilities of this method it is stated that Doctor Fischer has obtained from 1 cu. m. (35.3 cu. ft.) of water gas 100 cu. cm. (6.1 cu. in.) of an oil boiling over a range of about 30 up to 200 deg. cent. (86 to 392 deg. fahr.).

As in nearly all catalytic processes it is necessary in order to avoid rapid poisoning of the catalysts to remove from the water gas certain impurities, chiefly sulphur compounds. This purification while adding to the cost of the process, has the advantage of yielding an oil free from sulphur and therefore specially suitable for use in internal-combustion engines. The catalysts used are mixtures of oxides of iron or cobalt or copper, the water gas being used at ordinary pressures. (Editorial in *The Chemical Age*, vol. 15, no. 368, July 17, 1926, p. 45, *gA*)

INTERNAL-COMBUSTION ENGINEERING (See Fuels and Firing: Anti-Knock Motor Fuels from Shale Oils)

Colo Diesel Engines

THE Colo Diesel engine is a four-cycle airless-injection machine in which a displacer piston is used in combination with a precombustion chamber. It is made with a small bore and high speed and is adaptable to mobile equipment and stationary service requiring small units.

Although the cylinder is fitted with the constriction or neck characteristic of most precombustion chambers, the throat is nearly as large as the chamber itself and would be incapable by itself of doing much throttling or exerting much of any other influence. However, the neck is substantially blocked off during injection and most of combustion by a steel plug screwed into the piston head. Every time the piston comes to the dead center the plug dips into the throat with sufficient clearance to avoid metallic contact. The size of the annular opening at the time when the plug is dipping into the combustion chamber throat may be estimated from the drawings reproduced in the original article.

As a piston approaches the top dead center during the compression stroke the entrance of the tip of the plug into the combustion chamber neck sets up a pronounced displacer action due to the rush of air from the diminishing space between the piston and the cylin-

der head. Just at the moment when the plug has entered, there is still considerable air left around the shank of the plug. By the time the piston actually reaches the top dead center practically all of this air must have flowed through the annular opening formed by the neck of the precombustion chamber and the plug projecting into it. The flow of air thus set up causes pronounced turbulence within the chamber, which is claimed to further the combustion of fuel as soon as it is injected.

Although there is probably a considerable pressure rise in the chamber as soon as combustion gets well under way, it is retarded in communicating itself to the cylinder and piston because the constricted passage remaining between the surface of the plug and the contour of the throat. At the same time this annular space probably forms a sort of orifice, through which the pressure rise due to ignition violently expels the chamber contents into the main cylinder space. The combined effect appears to be that of greatly assisting combustion by means of accentuated turbulence, and at the same time of preventing an undue pressure rise within the cylinder bore. As the diameter of the precombustion space is limited, it can easily be made of ample strength without unduly thickening its walls.

A somewhat unusual method of regulating fuel pumps consists in the use of a static bypass needle subject to hand or governor control. The wider the needle is open, the less oil is forced to the injection valve. The engine is furnished with one, two, three, or four cylinders, all having the same bore and stroke, namely, 4.821 in. by 7.087 in. and is rated to deliver 8 b.hp. per cylinder at 700 r.p.m. The weight of the four-cylinder engine including flywheel, silencer, fuel tank, and spare parts, is quoted at 843 lb. (*Oil Engine Power*, vol. 5, no. 8, August, 1926, pp. 486–487, 4 figs., *d*)

High-Powered Diesel Engines

IN AN editorial under the above title, it is pointed out that in spite of the fact that an increase of diameter is the most obvious method of obtaining greater power per cylinder there is a noticeable tendency to employ a comparatively small cylinder diameter with a long piston stroke and to rely upon the adoption of the double-acting principle coupled with the use of the two-stroke cycle and a higher average mean effective pressure as a means of obtaining higher powers. In this connection data are presented on the new Richardsons, Westgarth engine, where an attempt has been made to evolve an engine of the utmost simplicity and reliability. So far only an experimental two-cylinder unit has been built, but the cylinders are of the standard dimensions which it is hoped to adopt on larger units, the cylinder diameter being $26^3/_4$ in. and the piston stroke $47^1/_4$ in. Each cylinder develops 800 b.hp. with a piston speed of 710 ft. per min. and a brake mean effective pressure of 70 lb. per sq. in. the normal speed of the engine being 90 r.p.m. It is, however, hoped to turn out a six-cylinder unit having a speed of rotation of 125 r.p.m. which would develop 6650 b.hp., i.e., almost of sufficient power to drive a 5000-kw. generator. For this engine it is estimated that the total weight excluding the flywheel would be 310 tons, or 105 lb. per b.hp., which is extremely satisfactory. The cylinder covers are of identical form for both the top and the bottom half of the cylinder, the part to which the stuffing box is bolted on the bottom cover serving on the top cover to carry the mounting for the compressed-air starting valve, starting being effected from the top half of the cylinder only. The fuel is injected into the cylinder on the solid or airless system at a pressure of 6000 lb. per sq. in., and the nozzles in the fuel valves, of which there are two set diametrically opposite to each other, are so arranged that the jets of fuel spray more in a path tangential to the piston rod. Scavenging is effected through a belt of ports which slope alternatively upward and downward to the top and bottom half of the cylinder from a common scavenging air pipe, and exhaust is effected through longer ports arranged opposite to the scavenging ports. While the cylinder, cylinder head, and piston-cooling arrangements have been very carefully considered, with a view to reducing the average temperature in the cylinder, the compression pressure is only 350 lb. per sq. in. This necessarily involves a sacrifice of thermal efficiency, but it means a far more reliable engine with corresponding reduction of upkeep and maintenance charges. It will thus be recognized that in the recent design discussed above we have advanced appreciably toward the ideal of a thoroughly efficient and reliable Diesel engine of large power. (Editorial in *Power Engineer*, vol. 21, no. 245, Aug., 1926, pp. 281–282, *dg*)

New Trends in Diesel-Engine Design

IN A PREVIOUS article abstracted in the August, 1926, issue of MECHANICAL ENGINEERING, p. 848, the author showed some of the methods by which higher efficiencies may be obtained in the Diesel engine. In the present article he deals with accelerated combustion as one of these methods. In the case of accelerated combustion a finely atomized fuel is burned with a short flame so rapidly that no contact with the cold walls of the cylinder takes place.

With the ordinary injection of fuel oil into the combustion space the oil comes in contact with the cold walls, the frictional resistance of the compressed hot air not being great enough to interfere with the progress of large oil drops to which has been imparted a high

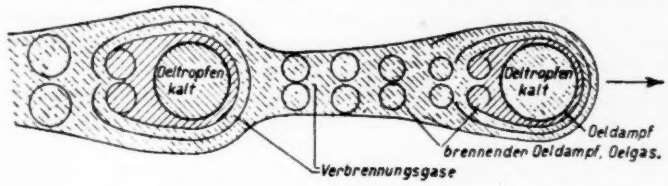


FIG. 3 SCHEME OF COMBUSTION OF A DROP OF FUEL OIL IN MOTION
(*Oeltröpfen kalt* = Cold oil drops; *Verbrennungsgase* = gases of combustion; *Oeldampf* = oil vapor; *brennender Oeldampf, Oelgas* = burning oil vapor and gases.)

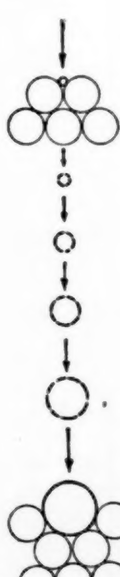


FIG. 2 VAPORIZATION OF A DROP OF FUEL OIL ON PENETRATION INTO THE HOT AIR OF COMBUSTION IN A DIESEL-ENGINE CYLINDER

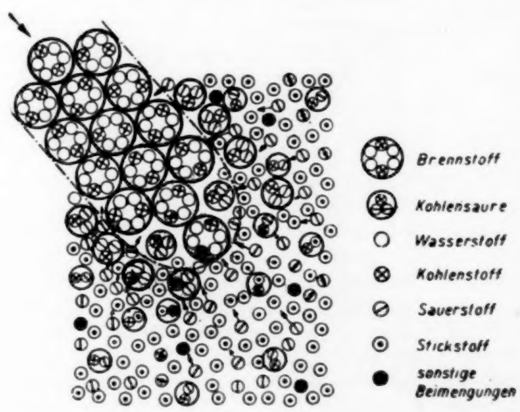
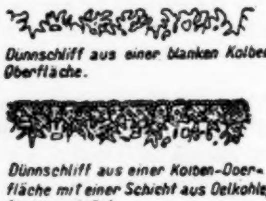


FIG. 4 SCHEMATIC REPRESENTATION OF THE CHEMICAL PROCESSES TAKING PLACE IN THE COMBUSTION OF A FUEL-OIL DROP
(*Brennstoff* = Fuel; *Kohlensäure* = CO_2; *Wasserstoff* = Water vapor; *Kohlenstoff* = Carbon; *Sauerstoff* = Oxygen; *Stickstoff* = Nitrogen; *sonstige Beimengungen* = other constituents.)

penetrating force. It is true that on its path through the hot air the oil drop takes up heat and is vaporized on the surface, and if this vapor adheres to the surface of the drop its diameter becomes greater and its frictional resistance is increased. This is shown diagrammatically in Fig. 2. Soon after its injection the vapor on the surface of the oil drop ignites while the interior of the drop remains cold, and the burning oil vapor and gases of combustion because of mass action remain with the drop as diagrammatically shown in Fig. 3. The supplying of oxygen to the oil-fuel molecule is made more difficult because of the presence of the gases of combustion and nitrogen of the air. Fig. 4 shows a probable distribution of the constituents of the air of combustion around an oil drop in air. From this it would appear that the oxygen molecules have to force a path through in order to be able to unite with the fuel molecules. Now the path from the injection nozzle to the piston body or cylinder wall is short and within a very short time, even before a fraction of the tiny drop has had a chance to burn up, the drop arrives, let us say, at the piston body and here it is faced with a new danger. Like hungry dragons there rise to meet it microscopically fine hair cracks in the piston material or pores in the oil-coke deposit, ready to absorb the oil. Fig. 5 shows how a thin layer of a clean piston surface looks under a microscope,

while Fig. 6 shows a similar surface covered with oil coke, this latter having absorbed some oil drops and having its surface wetted. It is only after one has gone through an investigation of this kind that he begins to understand why it is that combustion in a Diesel engine takes such a long time. Where cold-air injection is used the combustion is further disturbed by this cold air. In an airless-injection Diesel engine this source of disturbance is eliminated. On the other hand, however, it becomes necessary to atomize the fuel coarsely, because if it were atomized into a state of very fine subdivision it would not be able to penetrate into the hot air. The result would be that the fuel would remain floating in the air and large oil bubbles would form on the nozzles.



FIGS. 5 AND 6 (ABOVE) THIN LAYER OF A CLEAN PISTON SURFACE. (BELOW) THIN LAYER OF A PISTON SURFACE COVERED BY OIL, COKE, ASH, AND OIL

Fig. 7 shows what happens to the fuel in the case of the so-called jet atomization in engines equipped with hemispherical concave piston heads. The fuel strikes the hot piston head, scatters in every direction and in this way reaches the cylinder walls and cylinder cover. The temperature distribution in the combustion space takes place in some such way as indicated in Fig. 8. In the upper part of the combustion space there is created a zone (shown in deep black) where the temperatures are highest. In every other direction and, in particular, toward the colder walls, the temperatures rapidly recede. The injected fuel all passes through this hottest zone, and hence a different temperature distribution would be of advantage and may be obtained by proper heat insulation. In a combustion chamber shaped as shown in Fig. 7 the walls receive a large share of the fuel oil and this can come in contact with the oxygen of the air only as a result of gradual vaporization. The consequence of this is that in the neighborhood of the walls, zones are created where after-combustion takes place, and Fig. 9 indicates diagrammatically the approximate distribution of these zones of after-combustion. Lindemann shows (in *Zeitschrift des Vereines deutscher Ingenieure*, no. 52, 1924, p. 1355) that in the type V-M compressorless Diesel engine of the Deutz Motor Works the losses due to poor combustion are just as great as those due to the multi-stage compressor in engines with air injection.

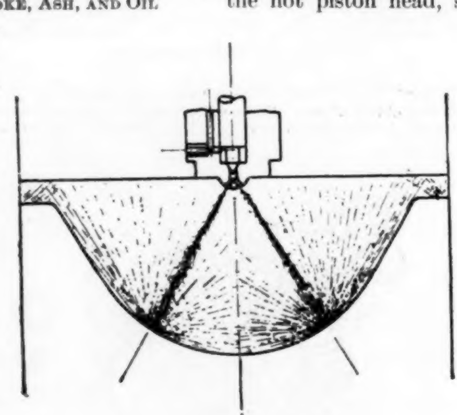


FIG. 7 JET INJECTION IN AN ENGINE WITH PISTON WITH CONCAVE HEMISPHERICAL HEAD

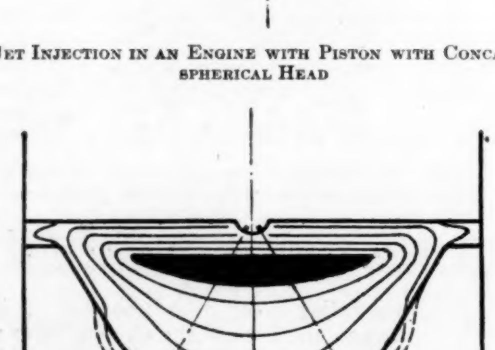


FIG. 8 TEMPERATURE DISTRIBUTION IN A COMBUSTION SPACE EQUIPPED WITH PISTON SHOWN IN FIG. 13

The deeply concaved piston acts as an incandescent body and because of this the lubrication of the piston must be given particular attention. Special care must be taken to see that the uppermost piston rings are cooled with fresh cylinder oil and that the formation of a smelly black lubricant is prevented as much as possible. Deutz employs a separate high-pressure oil pump for the purpose of piston lubrication. The oil, of course, overruns into the concave part of the piston, but is there vaporized and burns up together with the injected fuel oil. In machines of the precompression-chamber type similar conditions prevail, in addition to which the precompression chamber may be filled with exhaust gases and also with unconsumed fuel oil. Because of this the fuel consumption of precompression-chamber-type motors is somewhat greater than that of motors of the conventional type. [The original article gives a diagram illustrating the distribution of zones of after-combustion in a precompression-type motor.] Therefore an effort is made to make the passage between the precompression chamber and the combustion space as large as possible and the volume of the precompression chamber as small as possible.

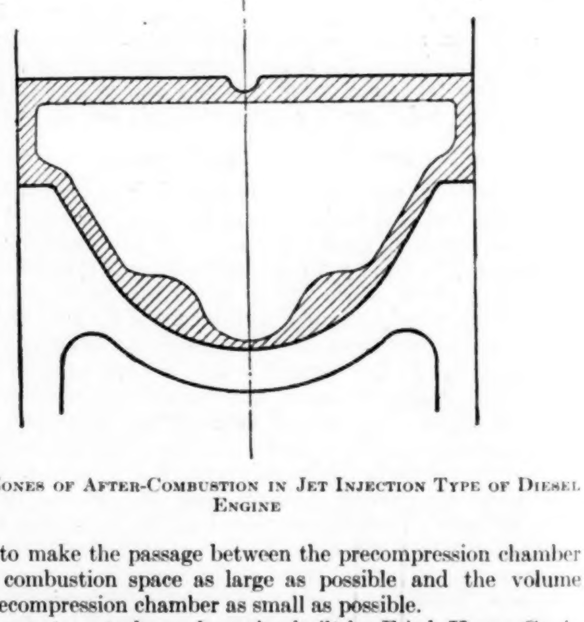


FIG. 9 ZONES OF AFTER-COMBUSTION IN JET INJECTION TYPE OF DIESEL ENGINE

In the new two-stroke-cycle engine built by Fried. Krupp Co. in Essen this passage is so wide that it is really more correct to speak not of a precompression chamber but of a more or less open space above the combustion space. (Continuation of a serial article by F. Ernst Bielefeld. Second installment, only part of which is abstracted. *Schiffbau*, vol. 27, no. 12, June 16, 1926, pp. 341–346, figs. 8 to 34, *pcdA*)

Special Type Piston for Oil Engines

A PECULIAR feature of the piston described here is that bands of steel are cast in the metal of the skirt, one above the piston pin and one near the bottom, with additional bands in other locations if required by the design. On each side of the skirt is cast a wave slot providing space to take up circumferential expansion.

Since aluminum and steel will not weld together at the melting temperature of the alloy, the steel bands remain free from the alloy though closely surrounded by it. The steel bands do not permit expansion in the direction of a diameter when the pistons are heated, but act as tracks to guide the motion of the metal around the circumference to partly close the wave slots in a circumferential direction.

Thus the slots grow narrower as the pistons become hotter, and wider as they cool again, while the only diametral expansion is that permitted by the enlargement of the steel bands themselves.

This is slightly less than the rate of expansion of the cylinder liner, so that instead of becoming tighter as the motor grows hot, as ordinary types of pistons do, a steel-band piston actually gives more clearance when the motor is hot than when it is cold.

Considerable importance is attached to this point because a heavier film of lubricating oil is needed to withstand high temperatures than when the motor is cool, and this variation of film thickness is provided for by steel-band control of expansion which gives more clearance at higher temperatures.

There is no squeezing-in of skirt at high temperatures to "set" to a shape which is retained when cool so as to leave the skirt undesirably loose after cooling and contracting. The steel bands avert much squeezing and maintain a skirt diameter conforming to the cylinder walls whether hot or cold.

The steel bands also serve to reinforce the piston, giving the walls of the skirt strength to withstand heavy punishment.

Tests were made with the new piston, among others, by the Winton Engine Co. and the Bessemer Diesel Engine Co., both of which adopted it for certain of their units. The article states that steel-band alloy pistons are now functioning successfully without any form of auxiliary cooling in sizes up to $16^1/_2$ in. diameter. Pistons of this design are cast of a special alloy of nickel, aluminum, and copper. The molten metal is not exposed to the atmosphere at any time, the purpose of this being to reduce oxidation to a minimum. (*Oil Engine Power*, vol. 4, no. 9, Sept., 1926, pp. 548–550, illustrated, *d*)

Piston Temperatures and Heat Flow in High-Speed Gasoline Engines

The paper here abstracted deals in the main with the results of the measurement of piston temperatures made by the author on various high-speed gasoline engines during the past seven years.

Temperatures were mostly obtained at different radii in the crown of the piston under full-load operating conditions. The first series of tests was carried out on an air-cooled aluminum cylinder of 100 mm. bore by 140 mm. stroke.

In order to investigate the effect of reducing the bearing area of the piston a series of holes was drilled through the piston walls. Thirty holes in all were bored with a total cross-section of 4 sq. in., representing a reduction of area of 12 per cent. The result of reducing the bearing surface is to increase the drop of temperature between piston crown and wall from 26 deg. cent. to 39 deg. cent. The temperature of the hottest point of the piston is increased by 11 deg.—from 207 to 218 deg. cent.

In other tests pistons of five different aluminum alloys and one cast-iron piston were used. The results show that there is sensibly no difference in the temperature of the various pistons with the exception of piston E, which is approximately 20 deg. cent. hotter than the remainder, at the center, under the full-load conditions. Piston E is made of an alloy containing 89.5 per cent aluminum; 8 per cent copper, 1.5 per cent tin, and 1 per cent manganese. The cast-iron and aluminum pistons were not of identical design. Among other things, the author arrives at the following conclusions:

Under normal operation conditions, at full load, the temperature at the hottest point of an aluminum-alloy piston of 100 mm. diameter, working in an aluminum air-cooled cylinder of good design, varies from 210 deg. to 250 deg., depending on the design of the piston and the composition of its alloy. This is with a clearance (cold) of about 0.025 in. With such a clearance the drop in temperature between the edge of the piston crown and the cylinder wall is from 25 deg. cent. to 30 deg. cent. An increase in the piston clearance increases its temperature.

A cast-iron piston of normal design and of 100 mm. bore has a maximum temperature of about 440 deg. cent. under the same conditions of operation. At medium compression ratios (about 4.7) and at 1800 r.p.m. it develops some 6 per cent less power than a good aluminum piston and requires a greater gasoline consumption (about 8 per cent) per b.hp. The relative advantage is, however, likely to depend on circumstances. Thus if the compression ratio is increased, detonation will first make its appearance in the cylinder fitted with the cast-iron piston, and a cylinder which would detonate violently with a cast-iron piston might work perfectly satisfactorily with an aluminum piston. Under these conditions the benefit of the aluminum piston would be much more pronounced. On the other hand, with a very low compression ratio the relative effect would not be expected to be at all pronounced. Recent experiments by the author on a $3^1/_2$-in. water-cooled cylinder with a compression ratio of 4.26 fitted with alternative pistons show that the improvement caused by the aluminum piston does not exceed some 2 per cent.

The design of the piston affects its maximum temperature appreciably. The best piston examined has no ribs and a comparatively thin center, the thickness of the crown being roughly proportional to the radius. This piston is some 20 deg. cooler than one of the same weight but of a heavily ribbed design.

The highest piston temperatures are attained with the weakest mixture capable of giving maximum power.

The temperature of the piston appears to be only very slightly affected by the compression, within the limits of the experiments, being slightly less with the higher compression ratios.

The effect of spark advance on piston temperature is not very pronounced, the highest temperatures, however, being obtained with the minimum spark advance.

In an air-cooled cylinder the hottest point of the piston is not at the center, but at a point nearer the hottest side of the wall. Even in a water-cooled cylinder the spark plug may have a very marked heating effect on the wall in its vicinity, and consequently on the piston. In an extreme case the temperature of the piston nearest the spark plug may even be greater than at that the center of the piston.

Assuming that the heat transference from a hot gas to a metal surface per second per unit area equals $e\phi^2$, where ϕ is the difference of temperature in degrees centigrade, the semi-amplitude of the cyclical fluctuation of surface temperature is given by

$$a = \frac{e(T_1 - \theta_0)^2 - (T_2 - \theta_0)^2}{2\sqrt{2\pi n\rho sk}}$$

For the piston and combustion-head surfaces, e has a value which varies from about 3.6×10^{-6} in gas engines of 6 to 12 in. diameter at speeds in the neighborhood of 200 r.p.m. to 11.0×10^{-6} in high-speed gasoline engines at about 2000 r.p.m. These values are in C.G.S. units. The corresponding values expressed in C.H.U. per sq. ft. per min., are 4.4×10^{-4}, and 13.5×10^{-4}.

When burning occurs in an aluminum piston, this is probably due ultimately to a local breakdown of lubrication, following overheating to a temperature which would not, however, in itself, prove destructive.

The discussion of this paper brought out a number of interesting points, only few of which can be mentioned here. Alan E. L. Chorlton (Mem. A.S.M.E.) stated that his firm tried magnesium pistons up to $8^1/_2$ in. diameter, but that a magnesium piston was a very difficult one to make, was very short-lived if it was a casting, and did not seem to have any advantages except that its light weight allowed of higher speeds. He also called attention to the necessity of considering the flow of heat through the rings.

In this connection J. F. Alcock (Ricardo & Co.) said that with regard to the question of the heat transferred from the piston to the cylinder wall by the rings, there were one or two facts which might be of interest. There were certain types of piston with which he had had experience, namely, the crosshead type and one or two trunk types, in which the skirt was separate from the piston crown and not very well connected to it thermally. In those cases it had been found that the clearance necessary had not been increased over that required by the ordinary type of piston having a skirt in one with the piston crown. That appeared to show that the rings transferred a fairly large proportion of the heat.

Engr.-Capt. G. W. Phillips said that considerable experimental work had been done with large pistons both at sea and in the Admiralty laboratories in connection with Diesel cylinders. The limitation of the size of the pistons was not, he thought, entirely a question of heat flow; it was partly due to the fact that after a certain diameter difficulties with the piston rings were experienced, due to the distortion of the piston by the higher temperature at the roof causing more or less of an arching of the piston. Eventually, if there was a small longitudinal clearance of the piston ring, the ring was broken by the piston arching over and getting the ring across its lands and breaking it by distortion

of the piston itself. If one tried to overcome that by giving an increased vertical clearance, he found the piston would last only a very short time, due to the fact that the upper rings, by virtue of the inertia forces on the clearances given, beat the lands out themselves, and the vertical clearance of the piston rings increased rapidly. One was therefore in a quandary.

He thought perhaps a few details of the experience which had been gained, particularly with the $14^1/_2$-in. aluminum piston, might not be out of place. This experience had extended over some three or four years under fairly arduous conditions at sea, and was to the effect that that size of piston (and possibly within narrow limits an increased size, though he would not go so far as the 20 in. mentioned by Mr. Chorlton) when carefully designed and running at about 360 to 370 revolutions gave satisfaction, provided certain definite principles were observed. They were frequently run at speeds of 380 in normal service, hour in and hour out; it was not a question of a ten-minute bench test.

In the first place, there was the question of skirt clearance. There again there were the two elements to contend with. If the skirt clearance was made too large, what was called piston "slap," which was very objectionable, was produced. If, on the other hand, it was very small, there was a risk of tearing the piston. He had known of engines which had run under apparently similar conditions for hour after hour, and then suddenly the engine would slow up; one skirt had started seizing. If one stopped the engine and examined the piston, definite surfaces of abrasion would be found. This was one of the points which should be borne in mind with regard to the use of copper-alloy pistons, which had been referred to. It would probably be found, except in the case of a very few alloys, that the resistance to abrasion would be so inferior that those pistons might be inclined to bite very early, unless they were given very large clearances.

Hammering of the ring grooves was one of the greatest difficulties which had been experienced. The ring was made longitudinally as shallow as possible, consistent with getting rid of the heat, and he thought the experience gained bore out the remark that the heat was chiefly transferred through the piston rings rather than through the skirt. Although undoubtedly there was a considerable transfer through the skirt, the great percentage went through the piston rings, where there was actual metallic contact.

Another point in regard to which considerable difficulty had been experienced was the leakage of lubricating oil past the piston. All sorts of experiments and all sorts of trials had been made, such as venting behind the lower piston-ring groove and making scraping edges for the bottom ring, relieving it back through the piston; and generally they had been fairly successful, but there was still a certain amount of difficulty, in that a piston which could be guaranteed to run reliably for days on end at something approaching full power would have such a clearance to insure reliable operation on service as would make it inclined to pass a fair percentage of lubricating oil. The consequent consumption of lubricating oil, although it was objectionable as being wasteful and reduced the endurance of the vessel, was chiefly objectionable from another point of view, namely, that it was liable to cause sticky exhaust valves. This defect could not be overcome by increasing the spindle clearance. A good deal of experimental work was still necessary to solve the problem of oil leakage past pistons, with the consequent liability of seizure of exhaust-valve spindles. (Paper by Prof. A. H. Gibson, University of Manchester, in the *Proceedings of the Institution of Mechanical Engineers*, no. 2, 1926; original paper on pp. 221–249, discussion on pp. 249–272, *e*)

MACHINE PARTS (See INTERNAL-COMBUSTION ENGINEERING: Special Type Piston for Oil Engines)

Iron for Piston Rings

An investigation of irons for piston rings (the author refers practically exclusively to work of German metallurgists) has enabled working out what might be called a general specification of cast iron suitable for each of the following requirements: (1) Low total carbon plus silicon content; (2) as fine a distribution of graphite as possible; (3) pearlitic matrix; (4) high manganese content, 0.8 to 1 per cent; this contributes to the formation of a fine-grained structure, reduction of sulphur and graphite separation, and increases heat resistance; (5) low phosphorus content, 0.3 per cent, producing an increase of strength; (6) low sulphur content, 0.05 per cent. producing also increase of strength; and (7) hardness 165 to 185 Brinell.

To produce this material it is recommended to add steel to the cupola melt so as to reduce the total carbon content. (N. Stern, *Der Motorwagen*, vol. 29, no. 21, July 31, 1926, pp. 479–487, 32 figs., *te*)

MARINE ENGINEERING

Ferry Boat with Gill Hydraulic Propeller

There are some exceptional cases of transport by water, when it is necessary to provide for a much greater flexibility in manœuvering than is usually obtainable with ordinary types of craft and propulsive machinery. Recently such conditions had to be met by a ferry boat for transporting passengers at the Royal Albert Dock, London, and a solution was found in an application of the Gill hydraulic propulsion system. It was found necessary in this ferry service to provide a small vessel capable of moving in any direction, either ahead or astern, and at any angle up to broadside on. A condition, which was imposed on the designers,

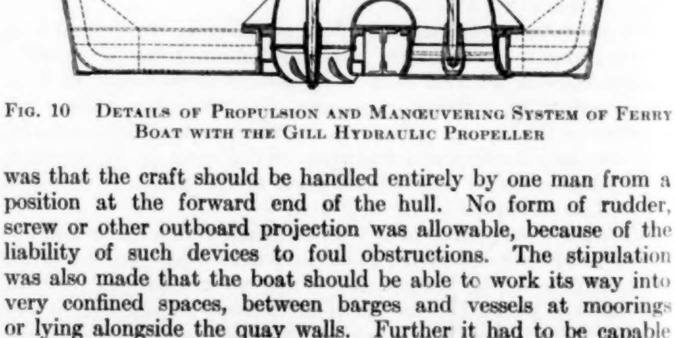


Fig. 10 Details of Propulsion and Manœuvering System of Ferry Boat with the Gill Hydraulic Propeller

was that the craft should be handled entirely by one man from a position at the forward end of the hull. No form of rudder, screw or other outboard projection was allowable, because of the liability of such devices to foul obstructions. The stipulation was also made that the boat should be able to work its way into very confined spaces, between barges and vessels at moorings or lying alongside the quay walls. Further it had to be capable of being held against quay-side steps or stages without the necessity for tying up. All the propulsion and steering mechanism had to be such as to be entirely free from possible troubles due to working in water encumbered with floating debris, ropes, and other obstructions.

It was decided by the Port of London Authority that the conditions could best be met by the proposals made by the Gill Propeller Company, Limited, of 17 Victoria Street, London, S. W. 1. These were that propulsion and manœuvering should be effected by the combination of an engine-driven Gill axial-flow pump with a siphon-shaped transfer pipe and a special adjustable type of discharge valve. The details of the propulsion and manœuvering system are shown in Fig. 10. The system of propulsion consists in drawing up water through a bell-mouthed inlet pipe, which opens flush with the bottom of the boat, and is shown to the right-hand side of the center line in Fig. 10. The water is lifted by means of a screw pump with a vertical spindle, driven by an oil engine. The water raised by the pump is passed through a short siphon pipe lying athwartship, also shown in Fig. 10. This deflects the path of the water through an angle of 180 deg. Leaving this pipe, the water passes through a variable-deflection valve, which discharges on the other side of the center line, but in any direction whatever, under the immediate control of the steersman. At the final discharge through the deflecting valve, much less area is available for the water than through the pump rotor, which,

of course, has a water path also less in area than the inlet. To obtain the minimum loss of energy these contractions of area were determined by a consideration of nozzle action. The reaction of the emerging water stream is used to obtain the propulsive effect, and as this may be developed in any direction, by varying, by means of the steering wheel, the setting of the rectangular orifices, which comprise the deflecting valve, complete mobility in manœuvering is obtained.

The molded boat dimensions are 30 ft. long, 8 ft. beam, and 2 ft. 9 in. depth. The steel hull is of unusually strong construction, for its dimensions, because of the hard usage to which it will be subjected and the nature of the service on which it will be employed. There is a large midship section for the accommodation of passengers, who are provided with battened side seats, entry being provided from the after deck by steps. The propulsion machinery and fuel tanks for the engines are located at the forward end. Two bulkheads are introduced here, to separate the machinery space from the other sections of the boat.

In addition to the acceptance trials, tests were made to determine the dead pull exerted by the vessel when under power, with the complete range of running up to the normal duty. These tests showed that the old empirical rule that a pull of a ton should be obtained with tugs and similar craft for every 100 hp. supplied to the shaft was complied with. (*Engineering*, vol. 122, no. 3160, Aug. 6, 1926, p. 167, *d*)

MECHANICS

The Application of Kutter's Formula to Gases

The present investigation is confined entirely to fluid friction when the density throughout the duct is so nearly constant that it may be so viewed. After briefly considering the basic formula for the flow of all kinds of fluids at constant density, the author proceeds to the question of the application of Kutter's formula for water to gases. Kutter's formula is recognized as a criterion for the flow of water, but it lacks the expression of the effect of density which is necessary for application to gases.

The correlation for the coefficients of gases attempted here is based on the hypothesis that Kutter's formula is correct in form for all fluids (i.e., for all densities). To make it applicable to gases, it is necessary first to discover the law by which this formula may be transformed in order to be applicable to other densities, and second, to compare the results of the transformed equation with existing data.

The author considers first several formulas for the flow of gases, such as the Babcock formula for steam, the Althaus formula for gas flow in cast-iron pipe, and the Goodenough formula for air in smooth concrete ducts, and then derives Kutter's constants for air and gases. He comes to the conclusion that in order to make Kutter's formula suitable for all fluids whether liquid or gaseous the only change necessary and warranted by the general data given is to divide y (which is one of the constants in the Kutter formula) by the specific gravity compared with water of the fluid under consideration.

A comparison of the results thus obtained with the results obtained by the other formulas would seem to indicate that on the whole the transformed equation agrees closely with existing data covering a very wide range. (F. Ernest Brackett, Cumberland, Md., in Paper No. 1578-A-F, issued with *Mining and Metallurgy*, June, 1926, 10 pp., 8 tables, *t*)

POWER-PLANT ENGINEERING

Limitations of Size of Turbo-Alternators

The development of large turbo generators is an example of the removal of successive limitations. In early practice large turbo-generators were built with axial ventilation. While this method of construction had many advantages, it inherently led to relatively high temperature rises for both the iron and copper because only a part of the cooling air passed through the high-loss zone and the temperature rise of the air through this zone was quite appreciable. In consequence of this, all-mica insulation was developed, which is satisfactory for 150 deg. cent. total temperature.

In order to obtain lower temperature guarantees, exhaustive analytical and experimental investigations on ventilation were undertaken by Mr. C. J. Fechheimer. These resulted in the development of the multiple-path radial system of ventilation. Similar studies are now being made on the ventilation of the rotating elements. As a result, ventilation and temperature rise are no longer limiting factors.

Another limit is mechanical rather than electrical. The developments in metallurgy have produced chrome-nickel steel for retaining rings, and better forgings are being produced. The built-up-plate rotor construction is admirably adapted for rotors of large dimensions where it is impossible to obtain satisfactory forgings.

A few years ago it was felt that critical speed would limit the lengths of rotors of turbo-generators. During the past two years comprehensive studies have been made on vibration problems, and as a result many previous ideas have been modified. For instance, where rotors were designed to have a critical speed higher than running speed, it was found in practice that the critical speed was below the running speed. This reduction in critical speed is due to the deflections in the pedestals, foundations, and other supporting material. As a result of these findings, large rotors are now designed to operate above critical speed, and any additional deflections in the foundations and other supports tend to widen further the gap which exists between critical and running speed.

The vibrograph has been developed for use in balancing, and by means of it accurate results are quickly obtained. Numerous studies have been made on the heat conductivity of insulation and laminations, so that fundamental data for design are now available. Improvements in the quality of iron laminations in order to reduce iron loss have been made through the use of silicon steel, following its successful use for this same purpose in transformers.

An important factor in turbo-generator design is the eddy current in the conductors due to the deep slots employed. Attention was first called to this by Field, followed by detailed mathematical analyses by Gilman. This resulted in the transposition of the strands of each conductor. During the past year further improvements have been made which will make possible the building of large generators. This has been done by a construction in which the coils having transposed strands, are made in halves, i.e., the coils are opened in the front and rear in order to facilitate insulating them and winding them in the machine. As it is impossible in such coils to connect each strand individually on the rear because of lack of room for the connections, a number of strands are joined together at the rear, and to reduce the eddy current between the strands the latter are transposed somewhere between the front and rear of the machine. The most desirable means is to transpose the strands within the slot. By this method the eddy-current loss factor in the winding can be made as low as necessary and another limitation as to size of machines has been removed, the above process being particularly applicable for machines with capacities greater than 62,500 kva. (Editorial by H. W. Smith in *The Electric Journal*, vol. 23, no. 7, July, 1926, p. 338, and article in the same issue by S. L. Henderson, pp. 348–351, *gd*)

Water-Cooled Furnace Walls

One of the latest developments in water-cooled-furnace construction with both arches and walls water cooled has been installed by the Western United Gas and Electric Company at Aurora, Ill. The surfaces exposed to the heat consist of cast-iron blocks having a refractory facing which are clamped tightly to tips connected with the main circulatory system of the boiler. This refractory facing on the blocks permits operation with the furnace temperature high enough for efficient combustion, while at the same time the water cooling holds down the temperature within safe limits. The construction is such that the wall is airtight, and therefore it is possible to vary the kind of refractory as well as the thickness of it as may be required in different parts of the furnace, or for different fuels, so as to give the furnace temperature that may be desired. (*Power Plant Engineering*, vol. 30, no. 14, July 15, 1926, pp. 787–789, *d*)

PUMPS

A Conical Rotary Pump

Description of a type recently designed by A. G. Mumford, Ltd., of Colchester, England, for oil fuel, brine pumping, and general work. The pump which is described has a vertical end joint, although similar pumps may be built with a horizontally split casing.

In the place of the impeller of the ordinary centrifugal pump is employed a cone-shaped worm which is furnished with spiral threads on its outer periphery. These threads may be varied in bore and pitch to meet different operating conditions, and their depth varies through the length of the worm (Fig. 11) so that desired area in the annular space between the worm body and the pump is obtained. Vanes are fitted on the end face of the worm body so that the pressure in the recess between the worm and the center of the end cover is reduced.

For pumps which have a suction lift, the inlet branch can be raised to any desired height so that a certain amount of water remains within it, making the pump self-priming. A pipe connection is fitted to preclude the possibility of emptying the pump and inlet branch passages by siphon action.

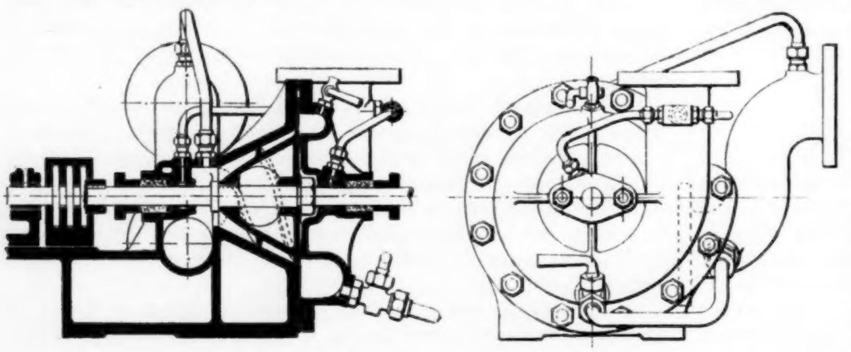


Fig. 11 Section and End View of Mumford Conical Rotary Pump

Tests were made on the 3-in. pump shown in Fig. 11 with a 2-ft. 6-in. suction lift and a 100-ft. discharge head. The speed was varied between 2660 and 3400 r.p.m. and the deliveries varied from 4480 gal. per hr. at the lower speed to 17,920 gal. per hr. at the upper limit. No information as to the power consumed is given in the original article.

For brine pumping the high pressure against which the new pump will deliver should prove an advantage should a block occur in the brine system. For high delivery heads two worms can be arranged on the same shaft, with the pumps so grouped that the discharge pressures will balance one another. (*The Engineer*, vol. 142, no. 3677, July 2, 1926, p. 17, illustr., *d*)

RAILROAD ENGINEERING

A Three-Cylinder Compound Locomotive

During the convention of the Mechanical Division of the American Railway Association at Atlantic City, the Baldwin Locomotive Company exhibited a three-cylinder compound 4–10–2 type locomotive. Among the features of this locomotive are a firebox with a hollow cast-steel mud ring and two horizontal upper drums with water tubes to replace the side water legs used in a boiler of the ordinary type. The front end of the mud ring is connected to the boiler barrel by two circulating pipes.

The cylinder casting is of iron, and is made in one piece. The inside cylinder is the high-pressure one, and its exhaust passes simultaneously into the two outside cylinders which are the low-pressure ones. All three cylinders are of the same dimensions. The high-pressure cylinder is connected to the second pair of driving wheels, and the two low-pressure cylinders to the third pair. The outside cranks are placed 90 deg. apart, while the inside crank is at 135 deg. with each outside crank. With this arrangement there are four even exhausts per revolution when the engine is working. The locomotive is started by admitting high-pressure steam direct to the outside cylinders through a manually controlled valve placed in the cab. Walschaerts valve gear is applied to all three cylinders. (*Railway and Locomotive Engineering*, vol. 39, no. 7, July, 1926, pp. 183–184, 1 fig., *d*)

Multiple-Pressure Locomotive Tests in Germany

This article refers to the tests of the Henschel multiple-pressure compound three-cylinder locomotive of the 4-6-0 type. The locomotive was built primarily for experimental purposes. Superheated steam at about 880 lb. pressure per sq. in. is used in a single high-pressure cylinder and the exhaust from this cylinder at about 200 lb. per sq. in. is combined with superheated steam at the same pressure drawn from the low-pressure section of the boiler to supply the two low-pressure cylinders.

The high-pressure section is a water-tube boiler similar in many respects to the Brotan type. Two-inch tubes set closely together form the sides, end walls, and top of the firebox. The lower ends of the tubes, forming the side and end walls, set in a hollow frame which supports the grates. Around the top of the firebox is a second hollow frame in the lower side of which are set the upper ends of the side- and end-wall tubes and on the inner side the tubes which extend across the top of the firebox. This system of tubes is filled with water about half-way to the upper frame. It can withstand the high temperature of the firebox on account of the small diameter of the tubes and the absence of scale. The small tube diameter is permissible on account of the fact that the small bubbles of steam generated from the small amount of water in each tube take about one-sixth of the space of the steam bubbles created in locomotive boilers of the usual design. The comparatively small space taken by the rising bubbles insures a good transmission of heat between the fire and the water. This system of tubes produces steam at about 1320 lb. per sq. in. The steam from this section is passed into a system of pipes placed inside a large drum which is centrally located above the top of the firebox. This drum is not exposed to the combustion gases, but is heated from the inside of the system of pipes carrying steam at 1320 lb. pressure. The heat from these pipes is transferred to the water in the drum surrounding the pipes, causing the steam in the piping system to condense. This transfer of heat generates steam in the drum at about 880 lb. pressure. The lower ends of the piping system to the inside of the drum are connected by outside pipes to the lower frame of the firebox which carries the 2-in. tubes of the side and end walls. By this arrangement the condensate from the heating pipes in the drum is returned to the tubes forming the firebox and is used over again. The high-pressure section of the boiler thus forms a closed circuit in which steam is generated from distilled water. The utilization of distilled water, of course, eliminates any possibility of scale being formed. Thus one of the great difficulties in the operation of the ordinary locomotive is overcome. No data of tests are given. It is stated, however, that it is reported that primary tests show an unusual economy in steam. (*Railway Age*, vol. 80, no. 38, June 26, 1926, pp. 1969–1970, *d*)

Divided Basket Bunkers on Railroad Cars

During 1923 and 1924 tests were run by the Bureau of Plant Industry, United States Department of Agriculture, to compare the performance of refrigerator cars of the so-called United States standard type, built following recommendations of the United States Railroad Administration, with that of a car of similar type except that in the latter the wire-basket bunkers were divided by vertical air spaces which effected reduction in the ice-carrying capacity and a considerable increase in the ice surface exposed to the air circulating through the bunker.

In the new car the bunker is divided into four distinct sections by longitudinal and lateral partitions. These intermediate partitions act as flues and allow air circulation around more of the ice than is the case of the U. S. standard type of recommended bunker construction. As a means of determining the comparative performance of the two types of bunkers two test trips were made using two cars of identical construction for each test, except that one was equipped with the wire-basket and the other with the divided wire-basket bunker.

A study of the results of this test would indicate that as far as the average fruit temperature of the middle layer is concerned, the difference between the two cars averaged only about 1 deg. throughout the trip. The car equipped with the divided wire-basket bunker maintained temperatures equivalent to those in the car having the U. S. standard type of wire basket, but quite a material saving of ice, 15 to 16 per cent, was discovered for the same cooling effect in favor of the divided basket bunker. (*Railway Age*, vol. 80, no. 38, June 26, 1926, pp. 1956–1959, 7 figs. *e*)

Turbo-Condensing Locomotive

This is the second article of a serial. The first was abstracted in Mechanical Engineering, vol. 48, no. 9, Sept., 1926. The present article presents the thermodynamic principles of the turbine generally and describes a turbo-condensing locomotive with toothed-gear power transmission. In this locomotive the first reduction of speed takes place through spur gearing in a gear box located near the turbine, and the second reduction takes place in the worm gears which are fitted to the axles of the driving wheels.

The casing of the first reduction gear box is made in three parts. The center part, which is a steel casting, carries the bearings and also forms another stretcher between the side frames. The upper and lower parts are covers which can be readily removed for access to the gears. The gear box also contains the oil pump, which provides the lubrication for all the bearings connected with the main

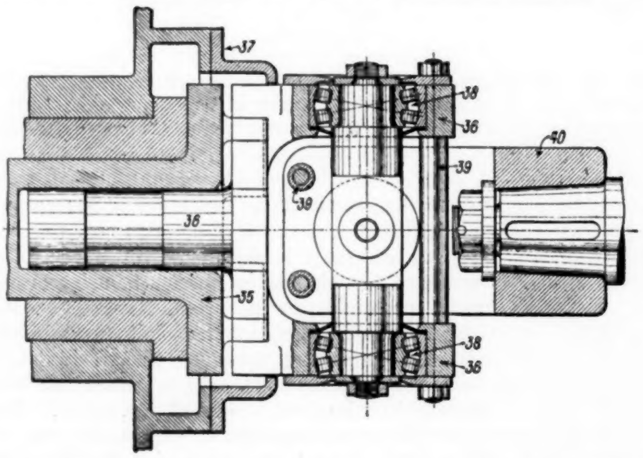


Fig. 12 Universal Joint in Gear Power Transmission on Turbo-Condensing Locomotive

turbine and gearing. Incorporated with the gear wheels is the reversing gear. The conditions which a reversing gear for a turbo-locomotive must fulfil are:

1 It must not be possible to start operating the reversing gear until the locomotive has stopped.

2 Neither must it be possible to start the locomotive until the reversing operations have been properly carried out.

3 It is essential that the proper positions of mesh should be automatically found so as to avoid all possibility of injury to the teeth by a clumsy driver. In short, the reversing gear should be foolproof

The worm gears which drive the axles are of the Lanchester type and are enclosed in cast-steel casings. The application of worm drives to locomotives may appear revolutionary, and the alternative to it is, of course, a double-reduction spur gear in conjunction with side coupling rods, but since with the former, outside springing and flexibility in the arrangement of the driving base can be secured, the adoption is to be strongly recommended. Each gear case is anchored by a rod, provided with ball and socket joints, to a stretcher.

The worm shafts are provided with universal joints, and these, together with the rods, give the requisite freedom of movement of each axle relative to the others.

Fig. 12 shows an enlarged section of the joint of each worm. The end of the worm shaft, 35, is flanged, and in the neighborhood of the rim of the flange there are formed projections which slide in corresponding recesses machined in the jaw forging, 36. These constitute the drive.

Since the flexible joint next to the gear box has to transmit the whole of the power generated by the turbine, it is necessary that the sliding surfaces be liberal and well lubricated in order to prevent wear. The lubrication is provided by the main oiling system, the overflow being caught by the cover, 37, and drained back into the worm-wheel casing. Each jaw of the joint is fitted with roller bearings, 38, capable of taking side thrust, and the bearings are enclosed in grease-tight and dust-proof casings.

The jaws are reinforced with tie rods and compression tubes, 39, to prevent any possibility of spring, for rigidity and absence of backlash are essential. The bearings of the gear case are supplied with oil under pressure from the main oiling system, which, after passing through the bearings, is returned to the oil reservoir, ready for use again. (George F. Jones, *Railway Engineer*, vol. 47, no. 559, Aug., 1926, pp. 285–289, 6 figs., *d*)

REFRIGERATION (See Railroad Engineering: Divided Basket Bunkers on Railroad Cars)

Dry Ice and Refrigeration with Dual Evaporation

In a lecture given before a joint meeting of the New York Chapters 1 and 2 of the National Association of Practical Refrigerating Engineers and the New York Section of the American Society of Refrigerating Engineers, J. C. Goosman of the York Manufacturing Co. described the most recent design of the York refrigerating machines.

He mentioned in this connection experiments made by his company with the so-called dry ice or carbon-dioxide snow. [This latter, by the way, is now used by an ice-cream concern to permit customers to keep ice cream taken from the store cold and solid for a period of 5 to 10 hr.] CO_2 congeals at —75 deg. fahr. and 50 lb. gage pressure; consequently the compressed liquid cannot be poured out like liquid ammonia or even liquid air. As soon as the liquid begins to evaporate the condenser becomes filled with a ball of CO_2 snow at —110 deg. fahr. Exposed to the air the snow does not melt to water but evaporates slowly because the film of CO_2 gas enveloping the ball of gas retards the transfer of heat. The ordinary dual system includes in addition to the parts of the old compression system the liquid cooler and regulating valve in the liquid pipe from condenser to liquid cooler. The vertical CO_2 compressor has the usual suction inlet at bottom for low-pressure suction vapor and above that an extra port for high-pressure vapor, from the liquid fore-cooler.

In the York machine a vertical, coil type of CO_2 condenser is used, the gas passing centrally in a pipe up to the top of the shell where it is sprayed over the coils. The early formation of liquid on the outside of the cooling-water coils keeps the greater part of the cooling surface moist for energetic heat transfer without interfering with the entry of new gas to be liquefied. There are three closely wound helical coils within the shell, each of same surface. This is attained by letting the innermost coil assume the diameter of the outer coil after 50 per cent of its travel upward and by letting the innermost coil expand to the largest diameter after it has covered 50 per cent of its length from top down. The center coil does not change its diameter. In this manner high velocity for both gas and water is obtained, and therefore a very high rate of heat transfer per square foot.

A pressure-ratio valve of the double-diaphragm type in the connection from condenser to liquid forecooler serves to maintain automatically a predetermined pressure ratio between these two vessels.

When the warmer liquid enters the shell of the liquid cooler under suddenly reduced pressure, a portion of the liquid boils and cools the remainder to a temperature corresponding to the reduced pressure, because it cannot obtain heat from outside, the shell of cooler being well insulated. Thus Calletet's experiment is duplicated, and liquid entering at a temperature above the critical is successfully cooled and made effective for refrigeration.

In this manner about one-half of the total CO_2 gas can be returned directly from forecooler to the compressor, the remaining cold liquid can proceed alone to the regular brine cooler, passing the expansion valve and evaporating at the low pressure required. It leaves the brine cooler near its top and then continues to the low-pressure suction inlet of the compressor.

The compressor functions as follows: During the downward stroke of pistons the entire cylinder becomes filled with cold low-pressure CO_2 gas. Just before reaching the lower end of stroke the top line of the piston uncovers a number of radically drilled port holes thus admitting high-pressure suction gas which crowds itself in and elevates the cylinder pressure to practically the fore-cooler pressure. The gain in capacity of compressor is proportional to the difference in the density of the low- and high-pressure suction gas, which is considerable. The efficiency of the evaporator is also increased because of the small volume of cold liquid required.

The lecturer showed by calculation that with ammonia dual evaporation and compression brought advantages only with a high- and low-temperature refrigerator, while with CO_2 a very material gain is obtained with a refrigerator of but one temperature. He showed that with the liquefaction or condenser temperature of 95 deg. instead of 86 deg. fahr. only 10 per cent more weight of CO_2 need be handled per minute per ton of refrigeration with an increase of 15 per cent in compressor horsepower. (Chas. H. Herter in *Refrigeration*, vol. 39, no. 1, July, 1926, pp. 43–44, *d*)

A Refrigerating Machine Without Moving Parts

In a previous issue of Mechanical Engineering, vol. 47, no. 7, July, 1925, p. 588, a description was given of a refrigerator without moving parts designed by two Swedish engineers, Platen and Munters. Another apparatus of the same type has now been designed by a German engineer, Altenkirch, and like the Platen-Munters, it is apparently suitable only for small outputs.

The theory of the Altenkirch scheme appears from Fig. 13. There *I* is the evaporator, the jacket of which is part of the brine circulation; *A* is the absorber, of which the liquid, kept cold by jacket *C*, stays unsaturated because of its flow from top to bottom in the column *K*. In the boiler *B* the liquid is reheated by the device *D* and loses its gas, which rises with it in the column *E*. In *F* the gas is separated from the solution, which latter returns to the temperature of the surrounding medium and goes back to the absorber. The flow of the solvent is obtained by the simple difference of the specific weights and by a judicious selection of heights of *K* and *E*. The gas in the meantime arrives at *G* where it is liquefied by a circulation of cold water, and then returns to the evaporator. Sulphuric acid is used as a solvent and water as a brine.

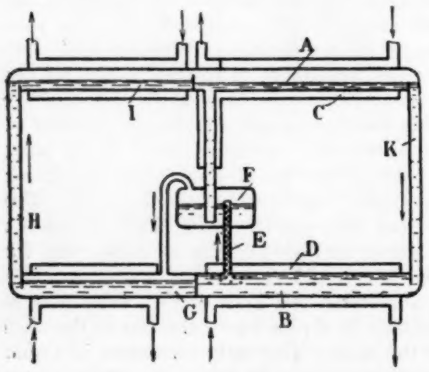


Fig. 13 Diagrammatic Scheme of the Altenkirch Refrigerating Machine

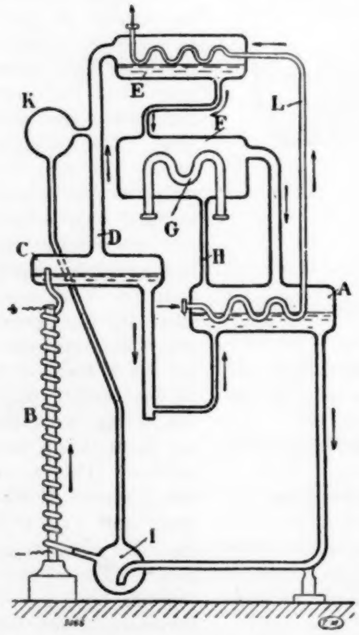


Fig. 14 Relation of Parts in the Altenkirch Refrigeration Machine

Fig. 14 shows the actual construction of the machine and its various circuits. Here *F* is the evaporator and *A* the absorber cooled by a circulation of water brought from the outside. The solution goes from *A* into *B* where it is evaporated under the influence of electric heat. In *C* the solvent and the gas are separated, the one going to *A* and the other to *E* where the gas is liquefied under the influence of a current of water coming from the absorber, then into *F* where it is vaporized, and as a consequence of this produces a refrigeration in the ascending column *D*. (O. Y. in *La Technique Moderne*, vol. 18, no. 13, July 1, 1926, pp. 408–409, 3 figs., *d*)

Water-Vapor Refrigerating Machine

There are obvious advantages in using water vapor as the circulating medium in a refrigerating machine, but there are also several generally known disadvantages. These have been partly eliminated in the refrigerating machine designed by Maurice Leblanc, extensively used on shipboard. These machines require, however, a large amount of circulating water which it is easy to provide on shipboard, but not always so on land.

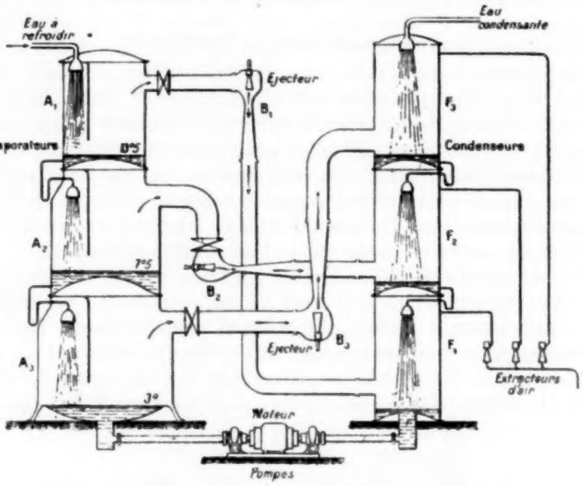


Fig. 15 Diagrammatic View of the Follain Multi-Stage Water-Vapor Refrigerating Machine

(*Eau à refroidir* = cooling water; *eau condensante* = condensing water; *extracteurs d'air* = air pump.)

The cause of the high consumption of water by the Leblanc machine is the use of the ejector, and a French engineer, R. Follain, proposes a modification which, it is expected, will obviate this source of trouble. This consists in using evaporators or condensers in several stages (Fig. 15). The following example will explain how this arrangement operates. Assume that it is desired to cool 2000 liters (528 gal.) of water per hour from 24 to 0 deg. cent. (75 to 32 deg. fahr.). This represents a consumption of 48,000 frigories and in a single-stage Leblanc machine would require an evaporation of about 80 kg. (176 lb.) of water.

Assume, however, that instead of a single evaporator three evaporators A_1, A_2, A_3, each provided with an ejector, are used; the first cooling the water from 24 to 16 deg. cent. (75 to 60.5 deg. fahr.), the second from 16 to 8, and the third from 8 to 0. Each evaporator will have therefore to evaporate only about 26 kg. (57 lb.) of water. The coldest evaporator A_3 discharges into the condenser fed by the cold water of condensation already available, and all that is necessary is to add to it the quantity required to condense 26 kg. (57 lb.) of vapor, to which latter should be added the motive steam, say, a total of 90 kg. (198.4 lb.). The same water slightly reheated will be largely sufficient to cool and condense the vapor coming from ejector A_2 at a temperature higher than the vapor that comes from A_1; this same water reheated in the second condenser may be used to condense the vapor issuing from the first evaporator A_1. The quantity of the necessary condensing water is, therefore, cut in three. Furthermore, the expenditure of vapor in the ejector is likewise decreased as only a third of the necessary frigories are produced at the final temperature, the other two-thirds being generated at higher temperatures. Hence, the economy in vapor, as consumption of steam by a given ejector decreases in proportions to the reduction of the difference of temperature created. The multi-stage machine has another advantage. At various seasons the water to be cooled may be at various temperatures and when it is entirely cold one or two of the stages of the machine may be shut off completely.

The article further describes an installation to produce 60,000

frigories per hour and also a machine to cool 3000 liters (851 gal.) to be used for condensation of benzol vapors. This latter machine requires 120 kg. (264 lb.) of steam per ejector or a total of 360 kg. (793 lb.) and consumes 20 cu. m. (706 cu. ft.) of water.

The auxiliary apparatus of this unit consists only of a pump to take the cold water from the last evaporator and another pump to take the hot water from outside of the last condenser, the two pumps being driven by a 3.5-hp. electric motor. (R. Villers, *La Nature*, no. 2728, July 17, 1926, pp. 46–48, 3 figs., *d*)

SPECIAL PROCESSES (See Fuels and Firing: Oil-Shale Extraction)

A Comparison of Open-Hearth Furnaces

AN ARTICLE essentially of interest to metallurgists. It gives, however, probably for the first time, certain data as to performance, costs, etc., of various furnaces. As these data are not generally accessible they are reproduced here in the form of tables.

TABLE 1 DATA ON STATIONARY AND TILTING BASIC FURNACES

Nominal rating, tons		Rated hearth area, sq. ft.	Weight of heats tapped, tons
Stationary	50	370 to 400	60 to 65
Stationary	60	440 to 475	70 to 80
Stationary	75	500 to 540	80 to 110
Stationary	90	550 to 600	110 to 150
Stationary	100	650	140
Tilting	200	675	225
Tilting	250	775	250 to 279
Tilting	300	825	250 to 400

There was at one time a serious doubt in the minds of steel makers whether as good a grade of steel could be produced in a large furnace as in a small one. The reports on this question are unanimous that equally as good-quality steel can be made with the large heats as the small.

One maker of sheets has gone from 110- to 150-ton heats with no change in mill practice. Another maker of high-grade carbon and alloy steel has increased his heats from 80 to 100 tons, and the results are so favorable that he is now preparing to make 125-ton heats. Another firm reports that practice with 110-ton heats as against 80-ton heats showed 0.4 per cent better yield of the mills, taken over an entire year's operation. The large furnace has been in use for a sufficient time to definitely establish that there is nothing to be feared as far as quality is concerned. The large heat assures better pouring practice when the proper design of ladle is used, as the loss of heat by radiation is less and more time and care can be taken in teeming.

Figures giving a comparison of a 75-ton stationary and 200-ton tilting furnace (Table II in original paper) are rather surprising

TABLE 2 VARIATIONS IN COST PER TON OF INGOTS—200-TON TILTING FURNACE

Fluxes[1]	+$0.075
Heating	−0.302
Total producing labor	−0.151
Total repairs and supplied (labor and material)	−0.171
Furnace rebuilding	−0.183
All other expense	−0.066
Total	−$0.798

[1] Burnt lime was charged on tilting furnace and stationary used raw stone.

in that the larger furnace does not show the saving expected although it has the advantage in heating, labor, maintenance, and rebuilding costs, the difference coming in the producing labor and rebuilding costs, which is not a reflection on the large furnace but rather on the method of operating.

The variation in the cost above net metal is given in Table 2 for the year's operation. All records in both shops were kept on the same basis, all materials were charged at the same price, and the wage scale was such that like positions made the same earnings in both shops. The stationary furnace is taken as the base and all differences shown on the tilting furnace. Thus the large furnace made a saving of 79.8 cents per ton on cost above net metal, which equals $88,290 for the year per furnace.

An outstanding feature is that the stationary furnaces averaged 236 hr. 9 min. per furnace for the year on repairs to bottom, while the large tilting furnaces lost only 15 hr. 10 min. per furnace.

The capacity of an open-hearth furnace of any given size is so dependent on the nature of the materials charged, the kind of fuel used for melting, and the quality of the product it is called upon to produce, that any comparison is worthless unless all these items are given the proper consideration. It is also necessary to standardize the methods of keeping open-hearth-furnace production records and to have a uniform system of showing the correct distribution of costs in order that a comparison of the operations of different plants will not be misleading. The author is emphatic in stating that inherently there is no reason why as good steel cannot be made in a large furnace as in a small one.

From the above it would appear that there is no very essential difference in results between the various furnaces, and that the selection of the type has to be made after the most careful consideration of all the factors involved. The large furnace, while it is able to produce at a lower cost, will not be able to displace entirely the 60- to 75-ton furnace in specialty shops, i.e., shops making a wide range of alloy steels for the merchant trade where only small tonnages are required of a given composition. (Stewart J. Cort in a paper before the American Iron and Steel Institute, May 21, 1926, abstracted through *The Blast Furnace and Steel Plant*, vol. 14, no. 7, July, 1926, pp. 302–307, *cg*)

Air Drying by Silica Gel

A GENERAL discussion of the subject of air drying, especially as applied to blast furnaces. The author states that chemistry has now in silica gel an apparently ideal adsorption medium. The vapor pressure of water vapor over activated silica gel lies between the values of concentrated sulphuric acid and phosphorus pentoxide. The energy required in air drying by means of silica gel consists essentially of the heat necessary to reconstitute the silica-gel material, and, depending on the size of plant and other conditions, amounts to something like 5×10^6 kg-cal. in 24 hr. for an output of 100 cu. m. per min. It is stated that the installation costs of a silica-gel air-drying plant are low in comparison with costs of similar plants of other types.

The author gives the following calculation, applicable, of course, to German conditions. Assuming a production of 1330 tons of pig iron a week, the blast required would amount to 565 cu. m. per min. Assuming two cases where the moisture content of the air is 7.65 and 9.6 grams of water per cu. m. of air, respectively, and a temperature of blast of 650 deg. cent., it would appear from the figures that an air-drying plant to take care of such an installation would cost 175,000 marks and that such a plant would pay for itself out of savings in a year. (F. Krull in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 70, no. 27, July 3, 1926, pp. 907–910, 2 figs., *g*)

VARIA

General Motors College at Flint, Mich.

A TECHNICAL college has been established by the General Motors Co. at Flint, Mich., where employees from the various General Motors units can be given specialized technical and practical training to fit them better for their work in the automotive industry. This college will be known as the General Motors Institute of Technology, will occupy a 10-acre campus near the Chevrolet Motor Company's plant and will provide educational facilities for 2000 students in day and night courses. The college will be operated on the same plan as that at Antioch College, Ohio, where students attend classes regularly for a while and then work in the shops. At Flint it is the intention of the corporation to make it possible for men taking the full-time courses to work in its factories for four weeks and then attend classes for the next four weeks. This will make it possible for students to finance their college education and at the same time gain valuable practical experience in actual work.

The course planned is intended to provide a junior engineering training and is designed to educate the boy to become an efficient and intelligent workman, a first-class mechanic, and a potential foreman or executive. (Lewis Dibble, *Automotive Industries*, vol. 55, no. 5, July 29, 1926, pp. 180–181, 1 fig., *g*)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Savings Through the Use of Standards[1]

SOME of the possibilities of saving in manufacturing costs due to an effective program of standardization and simplification combined, eliminating unnecessary types and sizes, and in some cases developing new sizes to correct a discrepancy due to omission or combination of certain sizes, are evident in the following items, which are partial results of a brief investigation along this line conducted by a large American manufacturer.

1 It was possible to reduce 130 stock sizes of steel and brass washers to 64 sizes, making a saving of about $3000 per annum in manufacturing costs and about the same amount in clerical and drafting expenses, effected by the reduction in diversity.

2 In some cases extraordinary reduction in diversity has been possible, as in the case of 1100 pins involving numerous duplications, mentioned in an earlier discussion (Reference SM Bulletin 8, page 6), and in cable cleats, where several hundred shapes have been reduced to 9, or certain punch fingers where 750 items were reduced to 75, with a saving of $7000 per annum. Two items of very large use, involving reductions of 60 per cent and 80 per cent, respectively, each brought about savings of $14,000 a year, and in one of these cases the standardization was followed by changes in design methods of manufacture, bringing about an additional saving of over $10,000.

3 Standardization of forms used in office work, although a reduction of only about 20 per cent was possible, brought about savings of $7500 per annum.

4 On the item of wood screws a 50 per cent reduction in variety was possible at an annual saving of over $4000, a rather surprising result considering that the plant in question is engaged in metal working.

5 Standardization of files, involving an elimination of 85 per cent, saved about $7000 a year.

6 On steel, brass, and copper tubing the savings totaled $7740, reflecting an average reduction of 50 per cent in variety.

7 Brass bars and sheets, on a reduction of 55 per cent in variety an annual saving of nearly $7000 resulted.

The savings in this one industry, while small in relation to total production, were large enough to amount to the total annual business of many thriving industrial plants.

When it is considered that in this plant the cost of setting up a tool for certain small parts was from $3 to $6, it will be seen how rapidly savings accumulate due to avoidance of unnecessary changes of tools from one style or shape of product to another.

The store-room cost per item of manufacture in this plant, exclusive of insurance, taxes, power and lighting, would average $45 per annum from which arises another evident large saving on the omission of any unnecessary item of production due to unification, although of course, on account of expenses involved in increased quantities of the standard product, there are costs which offset a part of this possible maximum saving.

In the Oil Fields

In discussing the standardization of oil-field equipment at a recent meeting of the American Petroleum Institute, an estimate was made of the savings to the industry through standardization. It was thought that 15 per cent might be saved on the $20,000, which the average well costs. On the item of belting alone, which is purchased to the extent of $5,000,000 per annum, in this industry, it was thought that through use of new specifications and through better care and usage in operation (resulting in part from standardization), about a million dollars per year might be saved.

On the item of rig irons it was estimated that the adoption of standards would save one and a half million dollars to the industry.

Probably 350 million dollars have been spent on rig irons since 1869, and yet these represent only about 5 per cent of the cost of the material required in drilling an oil well. The work of standardization has called for but $15,000 [annually, it is presumed].

One general estimate among engineers and practical men in the oil industry is that savings through standardization may extend to 25 per cent instead of 15 per cent.

[1] These statements were taken from the Sustaining-Members' Bulletin issued by the American Engineering Standards Committee on June 30, 1926.

Year Book of the American Engineering Standards Committee

THE 1926 Year Book of the American Engineering Standards Committee has made its appearance, and one cannot fail to be impressed by the fact that the movement toward standardization of industrial products has been considerably extended during the past year. The magnitude of the work may be realized when considering that 212 definite standardization projects are in process or completed under the American Engineering Standards Committee and that 365 national trade associations, technical societies and government bureaus are coöperating in the work through some 1581 representatives.

Many new projects of wide importance and interest are in process of development, such as the standardization of drawings and drafting-room practice, so as to provide a desirable uniformity in methods and conventions of mechanical and other drawings used in industry; the standardization of the methods of graphically presenting data of various kinds, etc.

Progress on some 50 safety codes applicable to factories, paper and pulp mills, elevators, escalators, etc., has been made, including an important code covering rock dusting of coal mines to minimize the coal-dust explosion hazard; which was recently approved by the Committee.

Extensive files of specifications of about 7000 standards are now available for examination and reference, which include those issued by foreign standardizing bodies with which regular exchanges of information and standards are made by the A.E.S.C. In addition to these, numerous bulletins are issued covering the work of standardization within individual companies.

The membership of the A.E.S.C. is now made up of 19 national trade associations, 9 national technical societies and 7 government departments. Charles E. Skinner, Assistant Director of Engineering, Westinghouse Electric and Manufacturing Co., is chairman of the Main Committee and Charles Rufus Harte, Construction Engineer of the Connecticut Co., is vice-chairman.

Copies of the Year Book may be had upon application to the A.E.S.C., 29 West 39th Street, New York.

Standard Specifications for Fire Tests of Building Construction and Materials

THE Sectional Committee on Standard Specifications for Fire Tests of Building Construction and Materials, organized under the procedure of the American Engineering Standards Committee held its seventh meeting at the Underwriters' Laboratories in New York. The Chairman, Dr. Ira H. Woolson, representing the American Society for Testing Materials, sent a message informing the Committee of his illness, and expressing regret at his inability to attend. On the unanimous request of those present Mr. George E. Strehan of the A.S.C.E., presided throughout the two-day session. The A.S.M.E. was represented on the committee by Mr. E. C. Rack of the H. W. Johns-Manville Company.

By common consent, all in attendance stood in silent remembrance of Virgil G. Marani, a valued member taken by death a few days following the preceding meeting. Mr. Marani was representative of the Gypsum Industries.

This Sectional Committee was organized to develop a series of fire-test methods applicable to assemblies of masonary units and to composite assemblies of structural materials for building. These

test specifications, which it develops, are to apply to bearing and other walls and partitions, columns, girders, beams and slabs, as well as composite beam and slab assemblies for floors and roofs. The committee also aims to make the tests applicable to other assemblies and structural units which constitute permanent integral parts of a finished building.

The performance of walls, columns, floors, and other building members under fire-exposure conditions is an item of major importance in securing constructions which are safe and not a menace to neighboring structures or the public. In testing building material and sectional-building assemblies under fire exposure, the control of the fire and temperature measurement is an important consideration and the development of this part of the specifications has been placed in the hands of a sub-committee. The report of the sub-committee on column tests brought out a lively discussion. This phase of the subject is of particular importance where columns of steel sections, as used in modern building, are affected by both heat and water during a fire exposure. A protective covering must be supplied particularly where the metal is exposed. The nature of such a protective covering and its application play important parts in the fire-resistant properties of a building when subjected to the heat of burning contents, as the failure in any one part may cause a series of failures due to the added loads. The standardization of specifications for fire tests of columns involves, of course, such questions as length of sample, method of loading, test after exposure and the application of stream test as well as many others.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

CO_2 and Excess Air

To the Editor:

I am referring to the article, Limiting Factors in Reducing Excess Air in Boiler Furnaces, by E. G. Bailey, published in the July issue of Mechanical Engineering, pp. 703 to 709, inclusive. I wish to compliment Mr. Bailey on the vast amount of valuable and interesting data contained in his paper. I also wish to say that the data, as shown by Mr. Bailey, are the best proof ever shown that the record of CO_2 in the flue gases, as a guide for combustion, is more positive and more certain than a record of the draft through any part of the boiler with possible reference to excess air as outlined in the paper.

What is excess air?

In my opinion the term "excess air" as talked about is more or less an imaginary quantity as far as practical operation of a boiler furnace is concerned. The quantity of air supplied for combustion is in no case determined directly as such. Given the products of combustion together with the analysis of the fuel, it is possible to determine the amount of air supplied and the theoretical quantity of "excess air." This determination is of interest when figuring out boiler losses, but its following is too uncertain to direct operation; and, besides, the "excess air" or even the total air is not the determining factor for best operating conditions, as ably demonstrated by Mr. Bailey.

The "excess air," as stated, is a derivative quantity determined empirically from the combination of other factors. Let us see from Mr. Bailey's data what criterion it is in comparison with these factors. I will ask the reader to examine Fig. 2,[1] which is the basic figure for the title Limiting Factors in Reducing Excess Air in Boiler Furnaces. Was the best operation determined by "excess air?" No. It was refractories, or rather furnace temperature in some cases, the appearance of CO in other cases, smoke and ashpit losses were responsible for still others. The "excess air" varied at will as graphically demonstrated in Fig. 1.

Now turn to Fig. 3, and note "the plots of several of the more modern plants." Observe the pulverized coal tests, P_1 to P_6, inclusive. Note the slope of each curve and the relative positions of the curves to each other. P_1 follows a straight line almost vertical. P_2 carries the same shape with a reduced slope from the horizontal. In P_3 the slope is still further reduced, and so is P_4 with a slight curvature in its shape. P_5 is a straight horizontal line, and P_6 is a curved line, part of which is diametrically opposite to P_4 and the other part diametrically opposite to P_1. The reason, as given by Mr. Bailey, is that the control factors in each case were the refractories, the smoke, the ashpit loss, the clinker; while the excess air was an incidental quantity that could not be heeded in view of the more important factors.

See further the comparison of C_1 and C_3 on the same map of modern plants. Both cases have the same construction of forced-draft chain grates, front arches, water boxes, etc. The relative size of the furnace volume to boiler surface is practically the same in both. There is a slight difference shown in the coal; that C_1 had a fusing temperature of 1900 and C_3 had a fusing temperature of 2000. With this difference C_1 registers the excess air at the top of the diagram with a minimum of 47 and a maximum of 57 per cent, while C_3 has a straight horizontal line on 21 per cent excess air. It is absurd that excess air should be used as a guide when variations of that nature are shown for best operation in the more modern plants.

Fig. 4, the combustion diagram, is the first introduction of the *real* factors, the flue-gas temperature, the O_2, the CO, and the CO_2. Curiously enough this figure is plotted against total air. The products of combustion, however, contain also the weight of the combustible and the water vapor in addition to the total air. Mr. Bailey learns from this diagram, "For furnace *B* the most efficient point is with about 12 per cent excess air; for furnace *C* it is 30 per cent excess air, while with furnace *D*, 70 per cent excess air is the most efficient point; that is, provided no other factors except CO and excess air are considered." What I have learned from this and similar diagrams is that for furnace *B* the most efficient point is 16 per cent CO_2, for furnace *C* it is 14 per cent CO_2, for furnace *D* it is 11 per cent CO_2. The difference is that in the case of CO_2 the operator is aiming at something real and he can use his good judgment to attain it; while in the case of excess air he is aiming at something more or less imaginary and uncertain.

Passing Figs. 5, 6, and 7, which are theoretical adjuncts of excess air, we come to Fig. 8. This curve gives the relation between CO_2 in flue gases and excess air for various fuels. I quote Mr. Bailey's introduction to this figure.

> It is rather lamentable that so many people consider CO_2 and excess air as synonymous, and it is safe to say that the majority today refer to combustion conditions by stating the percentage of CO_2 obtained rather than by referring to the percentage of excess air. Most people have stopped with this one figure, oftentimes feeling that it represented the whole story of combustion efficiency. The author would like to emphasize that this is not the case, for the percentage of CO_2 desired with any given fuel depends upon the chemical composition as shown in Fig. 8, ranging from $7^1/_2$ per cent with coke-oven gas to 22. 8 per cent CO_2 with blast-furnace gas for 20 per cent excess air. Even with the different kinds of coal the CO_2 varies more than 1 per cent for the same excess air. It is becoming more and more common to change back and forth from one kind of fuel to another, such as coal, oil, or gas, and oftentimes to burn a mixture of gas and pulverized coal or other fuels in the same furnace simultaneously. It is therefore quite important to analyze the flue gas for more than CO_2 to determine the percentage of excess air accurately.

The reader will realize from the introduction that Mr. Bailey confused the issue between proper combustion as indicated by the

[1] The figures referred to appear in E. G. Bailey's paper.

percentage of CO_2 and excess air as indicated by the percentage of CO_2. The majority today who "refer to combustion conditions by stating the percentage of CO_2 obtained" are correct for the part they are referring to. They do not refer to excess air, because it is at best an uncertain quantity. If one is curious to know the excess air for a given combustion, he can obtain it more directly and more easily from this Fig. 8, than from any other diagram in the paper, but for actual guide in boiler operation "the majority today" desire to have the record of the percentage of CO_2 obtained and compare it with the best obtainable, which is well known from the composition of the various fuels. It so happens, which is the main point in favor of CO_2, that the most common fuels used in boiler rooms require approximately the same amount of CO_2 in the fuel gases for best operating conditions. I will ask the reader to draw a line through 12.5 per cent of CO_2 on Fig. 8. It cuts the oil curve at 22 per cent of excess air and the bituminous at 45 per cent of excess air, and these are just the figures given for best operating conditions on Fig. 1, for the named fuels.

This is just the point. It is not only "common to change back and forth from one kind of fuel to another," but even for the same fuel the so-called excess air varies "all over the map," as clearly demonstrated in this paper; while the CO_2 for best operation is nearly the same for all ordinary fuels in the boiler room. Then again when you base combustion upon the percentage of CO_2 you have an index which is obtained by chemical analysis which is positive and unquestionable and is perfectly understood by the fireman and the operator in the boiler room.

The uncertainty of excess air as a criterion is obvious from the method suggested in the paper. First determine what it should be and then determine what it is. Both of these determinations are to be referred to a common denominator—the drop of pressure across several passes of the boiler. In order that this differential pressure be indicative of the excess air, it is necessary, first that the composition of the fuel remain constant; second, that the "passage" through which the differential pressure is measured retain the same shape and area; and third, that the products measured be at a constant mean temperature or at a constant mean density. These are the very items which are required when measuring flow through a calibrated orifice in a gaged pipe. If, as Mr. Bailey suggests, we run certain tests and we arrive at a certain differential that indicates good operation, that differential will indicate the same operation if all the other factors remain constant. In cases where these factors do remain constant no other index is necessary, but in any case where a change is produced in the relative differential pressure it is necessary to ascertain first whether the other conditions are constant before using this differential pressure as an operating guide.

Every boiler house offers a distinct problem dependent upon construction of the boiler and furnace, kind of fuel, method of firing, furnace temperature, limits of the refractories, clinkers in the fuel bed, smoke regulations, condition of baffles, accumulation of soot and dirt on the boiler tubes, temperature and composition of the chimney gases, and above all the personnel of the boiler room. This latter is an uncertain quantity at the best. I quote from the paper again, "Before the days of the combustion engineer and before the CO_2 recorder and other similar equipment were available, every fireman used his more or less good judgment." Of course it is not satisfactory to depend entirely on the good judgment of the fireman. That is why the CO_2 recorder and other similar equipment were made available. It is imperative, however, to employ methods and guides that will not work against the good judgment of the fireman, to employ methods that are positive and reliable guides such as the CO_2 recorder, the flue-gas thermometer, and similar records whose intelligence is not subject to the momentary changes in the operation of the boiler.

J. M. Spitzglass.[1]

Chicago, Ill.

To the Editor:

I think Mr. Spitzglass has gone somewhat astray in his line of argument for we certainly agree that there is a definite relation between CO_2 and excess air for any given fuel having a certain carbon-hydrogen ratio. Therefore, it would make little difference whether you would use CO_2 or excess air as the term designating the relationship between used and free air in the products of combustion. The reason why I emphasized talking excess air is because that is then independent of the fuel or the carbon-hydrogen ratio and gives one a relative picture of the free oxygen or air in the products of combustion independent of what the fuel analysis may cause the CO_2 results to be for a given excess air.

When Mr. Spitzglass refers to Figs. 1 and 2 to prove that excess air does not mean anything because it varies at will, and that refractories, smoke, ashipit loss, and other factors determine the best operating conditions, he is evidently trying to state in other words that these limiting factors have required certain boiler plants to be operated with certain percentages of excess of air. These percentages vary with the ratings and this different equipment. The CO_2 would naturally vary correspondingly so that it would be no better guide than excess air for the operator to maintain certain desired conditions. In fact, CO_2 recorders to my knowledge cannot be so readily adjusted to indicate a given reading for varying percentages of CO_2 with boiler rating as can the excess air as indicated by steam flow-air flow.

E. G. Bailey.[1]

Cleveland, Ohio

Journal Lubrication[2]

To the Editor:

In dealing with radial difference between the journal and the brass, the assumption is made that a constant ratio of running clearance to the shaft radius will give an effective-pressure oil film over an equal angular surface in two bearings of widely different diameters. It appears to the writer that for a given clearance per inch of shaft radius this angle will decrease as the shaft diameter increases, because the actual thickness of oil in which effective pressure can be generated at a given speed with a given oil is constant.

The theory does not take end leakage into account. This is an important omission, because improvement in journal-bearing design as regards reduction of length is desirable, and with such reduction of length the effect of end leakage becomes increasingly important.

The modern practice of designing bearings according to the Reynolds theory of lubrication originated with Beauchamp Tower's experiments on journal bearings, and it was shown that the pressure-oil-film effect was produced by reason of the running clearance. This resulted in the development of thrust bearings where the oil wedge is produced by a pivoted-pad construction. A developed section of a journal shows that such a bearing is merely a single-pad bearing having a permanently backed-off surface and thrust bearings now are being made with permanently backed-off segments instead of pivoted pads. Although the possibility of saving in friction in ordinary journal bearings is usually less than was the case with the older form of thrust bearings, there are inherent advantages in the pivoted-pad construction even when applied to journal bearings.

According to the author's theory, a two-pad bearing embracing an angle of 120 deg. is inferior to a fixed, fitted bearing embracing the same arc of contact. This is not borne out by the writer's experience. For example, in the case of four 10-in.-diameter bearings fitted to the necks of some cold rolls running at 30 r.p.m., and loaded to about 1000 lb. per sq. in. in which two-pad pivoted bearings replaced fitted bearings, both embracing an arc of 120 deg., the saving in friction is from 75 to 90 per cent. The saving in this case is that between greasy friction and film lubrication, but even in cases where film lubrication obtains in bearings of the ordinary type, the reduction in friction is at least equal to the saving in length. The saving in length is usually the deciding factor. In the case of large bearings this is an important item, and is brought about without increasing the maximum unit pressure.

[1] Vice-President, Republic Flow Meters Co., Mem. A.S.M.E.

[1] President, Bailey Meter Co. Mem. A.S.M.E.

[2] A discussion, with the author's reply, of the paper by H. A. S. Howarth on A Graphical Study of Journal Lubrication (Part III), published in *Transactions*, A.S.M.E., vol. 47 (1925), p. 1073. The paper and discussion in condensed form appeared in Mechanical Engineering, vol. 48, no. 2, p. 131.—Editor.

In Fig. 45, the author suggests the use of non-pivoted, fitted, off-set, journal bearings, but the writer doubts whether in practice these would be found satisfactory, because the surfaces at the leading edge do not converge in the direction of motion, and are therefore incapable of generating the necessary wedge of oil to give eccentricity of the shaft to the brass. Furthermore, if such bearings were short axially in relation to their circumferential length the effect of end leakage would be considerable.

Michell's mathematical study, The Lubrication of Plane Surfaces, has enabled the problem to be solved for three dimensions. It applies equally to journal and to thrust bearings, and several hundred of the former bearings fitted with pivoted pads are justifying this method of construction.

The question of the number of pads in a journal is chiefly the practical one of insuring equality of loading. Where the load line on the journal bisects the radial reactions from the pivoting lines of two pads, the load is divided equally between them as shown by the author's Fig. 48.

H. T. Newbigin.[1]

Newcastle-on-Tyne, England

To the Editor:

Referring to Mr. Newbigin's comments, the author has not "assumed" but the two-dimensional theory "has shown" that a constant clearance ratio η/a will produce the same pressure range in two bearings of different diameters, but of the same angular length and position, provided the oil viscosity is constant and the angular velocities of the journals are the same. Added to this, the same should be true, taking side leakage into account, if the ratio of bearing width to journal diameter is the same in both bearings.

Although Reynolds explained Tower's results analytically by assuming a running clearance, i.e., a difference in curvature between journal and bearing, the author believes he did so because it was the only simple assumption he could make and have the film complete from end to end of the bearing. If Tower's bearing had been made with a leading angle more than half the total bearing angle, there is little doubt but that Reynolds would have solved the problem by means of the simpler case of the fitted bearing. The author has found that there is nothing about the fitted bearing that is inconsistent with its perfect operation. It is not more necessary to relieve the entering edge than it is to similarly relieve the edge of a fitted pivoted-thrust-bearing shoe.

Mr. Newbigin states that the use of pivoted pads in journal bearings becomes more advantageous as the bearing width is made shorter, but he does not state what the proportions are at which he would expect the single plain bearing and the two-pad pivoted bearing to be equally efficient when having the same width. Obviously a short bearing, whether pivoted or otherwise, must run with a higher unit pressure than a longer one on a given shaft. The higher the pressure, the better the workmanship must be to prevent seizure. The factor of safety must therefore not be overlooked. It is better to keep the bearing as simple as possible and improve its design and finish, rather than to make it more complicated and even have to resort to still greater care in design and finish, with doubtful advantage at the end. With full knowledge of the possibilities of simple journal bearings before him, the designer should have recourse to the pivoted type only when there is no better solution of his problem.

The roll-neck data given by Mr. Newbigin are admittedly not a fair comparison of the two types of bearings, because in one case there was the high friction of greasy surfaces and in the other the fluid friction of well-lubricated surfaces. The simple bearing, if properly designed, finished, and oiled, might have proved much superior to the pivoted-pad bearing. It is therefore desirable that the two types of bearings be carefully compared by test under identical conditions, each type being designed, built, "groomed," and "ridden" in the trial by equally competent and careful engineers. The author would gladly welcome the receipt of the data on such tests.

A. G. M. Michell's three-dimensional study of the lubrication of plane surfaces, to which Mr. Newbigin refers, is a most creditable and valuable piece of work. It still has the limitation that it is based on the constant-viscosity assumption. Michell's findings, while pointing in the right direction, cannot be applied directly to journal bearings, because plane and journal bearings are so geometrically different.

So far as the author is aware, there is no *complete* mathematical study of lubricated surfaces. Hence it is desirable that factors, determined by careful test, be applied to such theoretical studies as have been made, so as to place them before designers in as usable a form as possible.

H. A. S. Howarth.[1]

Philadelphia, Pa.

[1] Michel Bearings, Ltd.

The Earnings of Engineers

To the Editor:

The writer has noted the letter of Charles Jay Seibert on page 766 of the July issue of Mechanical Engineering, referring in turn to the letter from H. M. Dougherty, page 830 of the April issue, and is gratified to learn of the interest taken in this subject, which is important not only from the viewpoint of the profession but to the people of the modern world who are enjoying the fruits of engineering knowledge in nearly every phase of life.

Viewing the subject from an angle favorable for its practical consideration, we see this lack of proper remuneration of the engineer as being an unpropitious condition economically; and, seeking to change that condition, it is necessary to use sound economic tactics as a remedy.

We have agreed that engineers are not receiving adequate remuneration. If this is true, the fact must be admitted not only by the engineers themselves but by all who profit by their existence and their work, and those who engage engineers. When these three classes of people are convinced that the engineer as a type of humanity is a boon to society as a whole and a profit to business in general, it will then become a matter of concern to them in a practical way.

The writer once knew a farmer boy who was keen on modern methods but was rather outspoken in this way. A neighbor of the old-fashioned type was complaining about his cattle, saying that he could not seem to make them pick up flesh. The boy answered dryly, "Suppose you try feedin' 'em."

The modern farmer knows that he is the one who is responsible for the provision of good food and shelter. He depends upon the animal to do the rest if he just gives it a chance. The same thing is true of plants, and the sample principle holds true in business relations, and in dealing with human beings.

Now regarding the engineer, it was said that he is of that type that if he devotes much of his attention to self-advertising he will be wasting valuable time needed in his professional work to concentrate on producing the best results, first, for his employer, second, for his own profession and for business in general, and third, for the benefit of the whole people.

In many cases two well-selected and well-paid engineers can produce more and better results than three poorly selected and poorly paid engineers. The employment of poorly selected men in any line of work means the employment of more men of a poorer grade and the encouragement of poorer classes of workers—those who are naturally unfit, or who have little care as to the quality or results of their work—and the better workers are compelled to seek the level of those less competent.

The employment of carefully selected engineers means fewer men of a better grade, with results that are better in quantity and quality, therefore more efficient work, a lower general rate of costs, followed by a greater incentive to make use of engineers in more lines and a general encouragement to all who are in the profession to attain to a higher grade of proficiency. And the result of all this will be a higher grade of engineering service in all lines, and the employers, the business men and the public will be the great gainers.

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MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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Open Letter to Students in Mechanical Engineering

IN THE carefree atmosphere of your college campuses you are preparing to take up the burden which now rests upon our shoulders, to assume the responsibilities which we bear and to solve the problems which are confronting us, just as we took up the burden, the responsibilities and the problems of the generation which preceded ours. But the burden we surrender to you, the responsibilities we relinquish, the problems we leave unsolved are greater than they were when we were young and greater will they become as you grow older. We have done our little bit in that amazing complexity called civilization; it is your destiny to do more.

If we are leaving you a greater task, we are also, however, giving you better machinery for its accomplishment, for as engineering projects have grown, so also has engineering knowledge, and the little empiricisms of our generation are being replaced by the rational sciences of yours. What to us was static is to you dynamic, the vitality of living knowledge quickens it, and a completer understanding of the material forces of nature is opening locked doors, releasing imprisoned energies and organizing legions of chaotic powers for the advance of civilization. You have it in your hands to direct and control this advance.

Science has elbowed the classics from the curricula of your schools, but the fecundity of science has presented you, not only with possibilities of greater achievements, but also with the necessity of deeper study and greater knowledge. The simple mechanics and mathematics of our day, the elementary and imperfect physics and chemistry, the rudimentary electricity have been replaced by fields of knowledge too broad for any one man to master all, yet from this field we are drawing today the most practical applications to our everyday life. What to us was steel or iron has developed the most fascinating possibilities which you, as mechanical engineers, will use with the sure knowledge that certain elements in definite combinations will result in materials having the strength, ductility, hardness, or chemical resistant properties which you require, and you will find this metal not by blind groping after a hoped-for ideal but with a foreknowledge of what you want and how to get it. As we learned to read blue prints, so you will learn to read photomicrographs and no piece of steel, or cast iron or alloy will be able to hide from you once you have its metallographic portrait. Science has dissipated the fog of our ignorance; it has given you eyes to see the unseen.

We were confronted with the problem of getting the thing done; to you comes not only this problem but its more subtle phases of improvement. Our generation has wasted much of the earth's resources in order that you may have the knowledge whereby they may be conserved. What was fuel to us, to be burned for the heat of combustion, involves for you a complex and extensive science, the chemistry of combustion, the technique of firing. We dealt with lumps of coal; you are to deal with molecular energy. We pumped water into boilers, but to you it is a combination of chemical elements and compounds, as individual as yourselves, within which, under the action of heat, there are taking place many chemical reactions and electrical disturbances. Rust, pitting, scale, material failure will not be meaningless mysteries to you but obvious and controllable natural phenomena, which you can predict and prevent. Chemistry is to be one of your greatest tools, and the knowledge of chemistry is going to remove the scales from your eyes and enlarge your prophetic vision.

As engineering ceases to be merely an act and becomes a science, its methods cease to be sporadic and are subjected more and more to the government of economic law. It is not enough to know how to build a hydroelectric plant, or a steam plant. You must know whether to build it or not, where to build it and which to build. The responsibility is yours. Because of it men will find employment, make homes—possibly they will be plunged into financial ruin. Your clumsy fingers are thrusting themselves into the delicate fabric of social science, you are dealing with the blind passions of hereditary customs, the subtle influences of environment, for some you are kindling the light of future progress; for others you are multiplying possibilities for the festering of meanness, and cruelty and oppression. Let your knowledge of economics and the social sciences guide you in a right path and do not imagine that your ignorance of these matters can be condoned. An engineer's mistakes are terribly real and not easily forgotten.

In his poems glorifying the engineer, The Sons of Martha, Kipling concludes:

> "They cast their burdens upon the Lord,
> And the Lord he casts them on Martha's Sons."

It is to this fellowship of service that we eagerly await your coming. Let no man come to it without knowledge of the responsibility he assumes, and let no man belittle the extent of the technical knowledge with which he must equip himself. He comes into an advancing profession where lies and bluff and laziness will only ruin him. With it he must advance, or from it he will straggle out, unworthy or incompetent. Get what knowledge you can while you may, belittling none of it, and have a man's comprehension and respect for the man-size job you hope to fill. Our invitation to you to become one of us is a challenge to your ability.

More Heat from the Earth

INTEREST always attaches to attempts to utilize natural sources of energy, particularly those in which the use of gradually diminishing fuel supplies is eliminated. Since 1912 engineers and scientists have followed with interest the work of Prince Ginori-Conti at Larderello, in Tuscany, Italy, where the soffioni or steam springs, have been tapped for power development and chemical recovery.

In MECHANICAL ENGINEERING for August, 1924, page 446, Dr. Thomas T. Read outlined the sources of energy to be found in the internal heat of the earth, and on page 448 was presented a precis of the development in the utilization of subterranean heat in this country and abroad.

The Metropolitan Section of the A.S.M.E. on November 12, 1925, held a session devoted to the subject of subterranean heat which was reported in MECHANICAL ENGINEERING for December, 1925, page 1175. Statistics of the development at Larderello were presented by Prof. L. P. Breckenridge, and the work which has been done with the geysers in Sonoma County, California, was described by J. D. Galloway. George A. Orrok spoke on the Thermic Calculation of Subterranean Heat and showed that the heat content of a cubic mile of magma amounted to 63,000,000 hp-years.

Interest in this subject was revived at the seventh annual conference of the International Union of Pure and Applied Chemistry

held in Washington, D. C., September 14, 1926, when Prince Ginori-Conti again urged the use of subterranean energy.

"Volcanoes are the most impressive spectacular forms of manifestations of our planet's internal energy, but it is certainly beyond actual possibilities to attempt the use of such dangerous reservoirs of natural heat," said Prince Conti. "In the neighborhood of active volcanoes there often are, however, zones of minor activity such as solfataras, pertaining to extinct volcanoes, or steam springs on the outskirts of the main volcano.

"Such is the region of Vesuvius where we find the solfatara of Possuoli and the Phlegraean Fields.

"I certainly do not attempt to deny that there is some risk in tapping these zones. Experiments have been made at Possuoli and the first were not successful, but I happen to know that the attempt is being renewed, and I confidently hope that the outcome will be a different one."

Engineers are likely to think most generally of the power and heat possibilities of these natural energy resources, but it should not be forgotten that chemicals are also recovered for the steam. Industries have been established which produce boron and its derivatives. Accompanying the steam are such gases as carbon dioxide, helium, and argon, and the mother liquors from the natural steam springs contain ammonia. In the soffioni plants of Larderrello natural steam is utilized to its utmost possibilities so that power may be considered as a by-product of a chemical industry.

Solid-Fuel Engines

In recent tests at the U. S. Bureau of Standards an internal-combustion engine was made to run on grain dust. Substantially there is nothing surprising about it. Grain-dust explosions in elevators and food-manufacturing plants are, unfortunately, quite well known, and anything that will explode can be used in an internal-combustion engine. As a matter of fact the first internal-combustion engine ever built was designed to operate on black powder. It did not prove a success, but there is no question that with our knowledge of today, it would be a comparatively easy matter to make an engine that would run with such a "fuel." The only reason it is not done is that an engine runs better and cheaper on gasoline or petroleum oil.

Acetylene has also repeatedly been tried in internal-combustion engines, as well as liquids containing acetylene in solution. Here again the engine runs but is not economical, in addition to which acetylene scores the engine walls and piston head.

In the early days of the Hvid engine demonstration runs were made with it using all kinds of freak fuels—butter, lard, etc. Anything that will burn freely can be used as an engine fuel in a Diesel or semi-Diesel type engine, and the French, for example, are very much interested in this subject, because of the fact that in their African colonies they have vast possibilities for producing vegetable oils. If these oils could be efficiently used in Diesel-type engines, France would be relieved of importing fuel from abroad and thus helping to create an adverse balance of trade.

Alcohol alone or with other materials, such as benzol, ether, etc., is used quite extensively in non-Volsteadian countries. As a matter of fact, an ordinary automobile engine with a somewhat different head can burn alcohol quite efficiently. Moth balls, which means naphthalene, have attracted very serious attention of internal-combustion engineers in the past. But for one disadvantage naphthalene engines would be quite common, as the material burns very well and is comparatively cheap. The trouble with it, however, is that it is solid at room temperature and hence requires an additional jigger to make it fluid before the engine can be started. This is a complication which militates against its more common use.

Solid fuel in Diesel engines is by no means a new idea. As a matter of fact, the original engine of that name was designed by Doctor Diesel to use powdered coal. The first test of this engine proved, not only beyond doubt that powdered coal will explode in an engine cylinder, but did the exploding part so well that it blew up the engine and nearly killed the inventor. Further work has shown that better results can be achieved with a liquid fuel, like oil, and the Diesel has been a liquid-fuel engine ever since. Quite recently, however, in Germany, serious efforts have been made to go back to the powdered coal as fuel and apparently some success has been already attained.

The above, of course, does not include any reference to "doctored" fuel, such as additions of picric acid to gasoline by racing car drivers, etc.

Applications of Fusion Welding to Structural Work

From recent newspaper reports and announcements in the technical press it appears that the newest application of fusion welding, namely, to structural-steel fabrication, is attracting a great deal of attention. In this as well as a number of the other applications of welding, the industry has shown commendable forethought and caution in conducting suitable research to establish practicable methods and processes, and the success of these initial attempts appears to warrant further and more elaborate attempts. It is, of course, obvious that such well-directed research is wise and will tend to prevent both the uncertainties and possible failures arising from application of a new process in the mechanical arts.

A reference to the results of one of this series of investigations appeared in Mechanical Engineering for September, 1926, page 974. It is worthy of the careful study and consideration of those interested in structural-steel fabrication, as it points to the limitations as well as to the promises of the new application of the art. Conservatism is always commendable when new processes are under trial, especially when the apparent success of the initial results stimulate the newspaper accounts that have recently appeared stating that as a result of studies made by the American Society of Mechanical Engineers and others, electrically welded steel buildings may soon replace the riveted frame; in these reports reference is made to similar buildings that have been built by both the welding process and the customary riveting, with considerable advantage and economy attaching to the former process.

It is probably unnecessary to attempt to correct the impression broadcast by such newspaper accounts that the Society is making "studies" on this particular subject, as there is no more foundation for such a claim than that the subject entered into the discussion at a joint meeting of our New York Local Section and the American Welding Society last November. The Society under the terms of its Constitution disclaims credit for any such reflection as the discussion of any particular subject at its meetings may throw toward any branch of the industry, but at the same time it welcomes discussion on all subjects of general interest, as it is considered of the greatest benefit not only to the engineering profession but to industry at large. Only in this manner can the rapid advances in engineering practice be made broadly available, and the members of our engineering bodies kept abreast of progress.

Furthermore, when such reports are circulated that threaten replacement of one art or practice by a new and improved method, it should be remembered that this is typical of the development of engineering and the mechanical arts. The dream of today is to become the realization of tomorrow. Just as the automobile has advanced from an experiment of a decade ago to a necessity of today, aerial navigation which is now passing through its elementary stages promises to rival the automobile in popularity a few years hence. The engineering profession is therefore warned to be everlastingly on the lookout for advances of the most rapid and revolutionary character as progress unrestrained should be welcomed.

Second Edition of Principles of Metallurgy

In Mechanical Engineering of 1925 a series of articles by Leon Cammen, were published under the title, Principles of Metallurgy of Ferrous Metals for Mechanical Engineers. These articles with substantial additions were published in book form under the same title as the original series. The first edition issued in February, 1926, has been exhausted, and a new addition has now been published. This contains some additions to the bibliographies at the end of each chapter.

Progress as Exemplified at the New Haven Machine Tool Exhibit

SINCE the building of machine tools ceased to be a sideline in the manufacture of firearms and became a distinct industry, some sixty years ago, it has passed through several revolutionary changes, interspersed with periods of steady improvement. Of the causes of revolutionary changes there may be mentioned the introduction of automatic control by the later Christopher Miner Spencer in 1873 and the introduction of high speed steel cutting tools by the late Frederick Winslow Taylor in the early part of the twentieth century.

Such inventions as these have caused sudden overturns in accepted standards of design, followed by periods of refinement in the new designs during which there was a general clearing out of the machines of the previous epoch in shops requiring high speed and low cost production of accurate parts such as those entering into the manufacture of sewing machines, bicycles and more recently of motor cars.

To a thoughtful observer of the machine tools industry, there is evidence of the ending of another epoch and the beginning of a new one which is now well advanced in the refinement stage. Specific mention in this case cannot be made of the *one* thing which has brought about the change, rather it is a number of developments which came along about the same time. These have appeared at a time when the automotive industry, now by far the greatest user of machine tool equipment, is spurred by popular demand to seek maximum speed and split thousandth accuracy and by fierce competition to seek minimum production costs.

The Sixth Annual Machine Tool Exhibit at New Haven, September 7–10, furnished an unusual opportunity to study the developments in question. The most noticeable was the increasing application of automatic control to machines other than screw machines. This was well exemplified in a bore grinder which carried out its entire cycle of operations, even the exact gaging of the bore dimension, from the time the work was chucked until the finished piece was removed, all this without the intervention of the operator.

The effect of the individual motor drive upon designs is another marked characteristic. Not only does one motor drive one machine but this has been carried further by subdividing the separate functions of one machine and applying an individual motor to each function, thus eliminating complicated mechanical power transferring mechanisms. At the same time the motors, which formerly had the appearance of unwholesome excrescences, have been merged into the ensemble to appear a natural part of it. The same applies to change gear boxes, pumps, cam mechanisms, covers and guards. These last, by-the-way, show that the safety movement is being heeded among machine tool designers.

Centralization of control seems to have been generally recognized as desirable. The adoption of push button switches, hydraulic feeds, pneumatic chucking and the increasing use of the "station type" machine, in which the work comes to the operator instead of the operator following the work, have helped to bring this about. By the grouping of the push-button switches, as well as the manual-control levers, at a strategic point it has become possible for instance to entirely operate a large radial drill from the ideal working location.

Ball and roller bearings are now applied not only to machine-tool bearings of minor importance, but with the coöperation of the bearing manufacturers now been made available on spindles such as those of lathes, screw machines, and grinders. Spindles so equipped are driven at hitherto unheard of speeds without heating or vibration. This permits small grinding wheels to be driven at proper surface speed and small diameter stock to be turned at maximum efficiency.

It is plainly evident that the punch press is penetrating fields previously dominated by conventional machine tool methods. Gas and electric welding supplements the presses by building up pressed metal into parts formerly made only of machined castings, forgings, bars or plates. At this point it may be mentioned that a motor-driven pantograph machine was shown which cleanly and accurately cut any design from heavy steel plate. Die-cutting machines are fully keeping pace with the increasing use and complication of dies and the decreasing number of trained hand die-sinkers. A die-cutting machine under demonstration made use of a very sensitive electro-magnetic "feeler" following the outline and contours of a plaster model, to rapidly and exactly reproduce this model in a block of tough die steel, through the medium of a powerful revolving cutter controlled by the "feeler."

To sum matters up it may be said that machine-tool builders are freely calling upon science to help them in their problems, and never before has so much real engineering been embodied in their creations.

The distinct beauty of the clean lines of the best designs literally embodies the rugged strength, the tremendous power and yet the delicate accuracy of the machines. This goes far toward proving the truth of the adage long prevalent among designers that "What looks right is right."

Household Mechanical Refrigeration

A REVIEW of the past decade will disclose many interesting developments in the field of mechanical engineering, but one will find few stories more fascinating than that of the growth of household mechanical refrigeration.

About ten years ago electrical show visitors were attracted by a display on which an extraordinary refrigerator producing ice, instead of consuming it, occupied the central position. The average visitor, however, left the exhibit with the well-formed opinion that the machine was satisfactory for the wealthy class, but not for him, especially when his daily supply of refrigeration was insured by the simple process of hanging an ice card in the window.

The World War, however, placed our food situation in a new and strange light. We saw tons of perishables transported over seas and then by rail for additional miles to be stored for long periods in gigantic warehouses. Gradually the world began to realize that the unseen agent responsible for the success of these feats was refrigeration, mechanically produced. The gradual assimilation of this fact by the average individual produced startling results. The failure of the iced refrigerator to hold its contents satisfactorily when the ice reached a low level set the owner to wondering if this new ally which made possible the feeding of a great army better than ever before, even to serving fresh desserts, might not also be made a valuable servant in the home in time of peace.

Manufacturers were quick to seize upon this manifestation of interest outside the novelty-seeking class, and immediately there followed a gigantic educational campaign to acquaint the housewife with the desirability of the mechanically cooled refrigerator. Many angles were presented, but these were finally reduced to the one all-important point, the prevention of food contamination over longer periods than were possible with ice. The natural desire of man to possess that which his neighbor has found attractive and desirable while there is yet a possibility of exhibiting it as an object to excite envy in the hearts of his more unfortunate friends, has helped to popularize the machine.

It is interesting to note the increase in sales and earnings since 1920. One authority has estimated an average increase of 100 per cent per year up to 1925, with an increase of approximately 350 per cent for that year over 1924. Present indications are that even this figure will be exceeded in 1926. A $20,000,000 factory recently completed by one of the larger companies will raise the total daily capacity of that company to more than 1000 complete units. Another company has acquired a 35-acre plot upon which it will erect a building containing 600,000 sq. ft. of factory floor space and costing $5,000,000. This company will also invest $1,500,000 in improvements in one of the large cabinet factories, greatly increasing its yearly capacity and supplying a sufficient number of cabinets to adequately fill the requirements of the hundreds of thousands of both self contained and separated installations for home and market use to be produced by the company each year. The per share earnings of one of the leading companies in 1923 amounted to $2.01, this figure increasing to $4.32 in 1925. The first two quarters of 1926 showed earnings of $4.36 per share, or more than last year's total.

Well as these machines operate, however, it is a well-known fact that they still require the occasional attention of a competent service man. The elimination of this additional expense will

mean a lower priced machine and, more important, greater confidence on the part of the buyer. Here is a challenge to the mechanical engineer. The compressor, in most cases, is of the reciprocating type and subject to vibration and noise. The problem of retaining the refrigerant within the machine has not been solved to the entire satisfaction of all concerned. Compressor valves might be improved. Power transmission might be more economically and silently effected. Lubrication problems must be made so simple that they will require a minimum of attention. The ideal machine would be hermetically sealed, there would be no vibration, no noise, no valves to break or wear out, no motor or other electrical troubles, no lubrication problems, power costs would be reduced to a minimum; in short, the machine could be forgotten, yet it would continue to perform its duties faithfully. Further, and very important, each of the proposed improvements tending toward the ideal must be carefully weighed as to its effect on the cost of the machine, for unless this is held to the lowest possible figure there will be no appreciable extension of the field to include the individual whose income does not permit the indulgence in what he may term luxuries. A big order, certainly, and one not likely to be filled for some time, but with 10,000,000 homes in the United States wired for electricity and over 1,000,000 additional being wired each year, the field is most interesting.

Aircraft in Naval Warfare

NOT MORE than a couple of years ago many men prominent in the naval services of this country and abroad seemed to feel that at best the only uses of aircraft in naval warfare would be as scouts and gunfire spotters for surface and sub-surface vessels. Because of this, the article, The Offensive Power of Aircraft, by Lt.-Com. V. D. Herbster, U. S. Navy, in the September, 1926, issue of the *United States Naval Institute Proceedings*, deserves more than usual attention. Had this article been published by its author two years ago it would have been featured on the front page by every big newspaper from Maine to California. Such has been the change of attitude towards aircraft that its amazing statements will now be taken more or less as a matter of course.

The development of bombing of battleships from aircraft is in the opinion of the author the really big outstanding air job of the Navy. It seems to him reasonable to assume that several even comparatively small bombs landing on the deck of a battleship would do considerable damage to the upper works and fire control. Such a casualty at the beginning of an engagement would seriously affect the fighting efficiency of the ship. He believes (inhuman as it may seem) that many gas attacks on battleships will be made before or during the main engagement in the next big naval war. These bombs will contain gases that will be taken up by the ventilating systems of the ships. Gas bombs may really be considered the most dangerous weapon of the airplane. Very little is known at present as to the best tactics to be employed by airplanes carrying gas bombs when making gas attacks against a fleet.

While the possibilities for bombing are tremendous, there is still another phase of the offensive operations of aircraft that should be considered, i.e., the torpedo-plane attack. It is no exaggeration to state that the fleet was surprised by the coordination shown by the torpedo squadrons in making their attack on the fleet off Guancanayabo last winter. The destroyers probably took note more than others. They were also surprised, no doubt, at the results secured in that practice. The facts in the matter are that torpedo planes can launch torpedoes, have secured a big percentage of hits against surface ships in battle aircraft torpedo exercise, and furthermore have successfully delivered simultaneous attacks against the fleet. In a torpedo-plane attack a shore base is no longer required. Torpedoes are fired at close range and individual ship movements are of very little value; the present development of torpedo plane attacks has shown that both individual ship and division manœuvers are useless to avoid being hit.

Earlier in this discussion it was pointed out that combat planes will not be able to prevent bombing attacks. Neither will they be able to entirely prevent torpedo-plane attacks. The principle of concentration of gunfire is followed in aviation and applied to secure concentration of bombs and torpedoes against the target. This not only means that bombing attacks and torpedo attacks will be delivered by squadrons but also will sometimes be launched at the same time against enemy ships. What is the best method of delivering such combined attacks and, *vice versa*, what is the best way for the fleet to repel them or to defend itself against such attacks? Such questions can only be answered by the results secured from exercises with torpedo planes in the development of torpedo-plane tactics.

Aviation is steadily advancing in usefulness; naval aviation is steadily advancing in its work with the fleet. There are some, however, who do not realize that when the planes are in the air they become an air force, a force able and capable of offensive action against enemy ships. The goal of our fleet is the destruction of the enemy fleet; and to secure this victory we will use every weapon we possess. It is not a question of the battleship versus the airplane any more than it is a question of the battleship versus the destroyer. The big problem is to get the most out of every weapon and out of every ship (surface, undersurface, and above surface) so that the final result is a victory for the fleet.

The development of the offensive power of aircraft will have an effect upon the future design of ships, including carriers. It will probably settle the argument as to the size and number of carriers needed by the fleet. In view of the above statements, there can be scarcely any doubt that at least younger commanding elements of the Navy are thoroughly awake to the value of aviation.

Grants to Aeronautical Education by the Daniel Guggenheim Fund

THE Daniel Guggenheim Fund for the Promotion of Aeronautics was established by Mr. Daniel Guggenheim last February, with a provision for supplying $2,500,000 as needed by the Directors. The Fund is unique among the large foundations of the country in that its founder did not contemplate a permanent foundation, but merely made provision for sums which would make possible experiments and developments on a large scale in aeronautics in the early stages of this great industry. The establishment of the Fund followed the foundation of the Daniel Guggenheim School of Aeronautics at New York University, and among the first acts of the Trustees of the Fund is the provision of grants to promote aeronautical education and research in two great institutions on the West coast; namely, Leland Stanford University at Palo Alto, and the California Institute of Technology at Pasadena, Cal.

The California institutions were notified of the grants by Harry F. Guggenheim, son of Daniel Guggenheim and President of the Fund. In his letter to Dr. R. L. Wilbur, president of Leland Stanford University, Mr. Guggenheim outlined the purpose of the grant and also drew attention to the achievements of Dr. W. F. Durand, Past-President of The American Society of Mechanical Engineers, and known to mechanical engineers throughout the country:

> The gift is made in recognition of the quality of work which is done in your school of engineering by Dr. W. F. Durand and his associates, and also because of our belief that in the great educational institutions of California such important contributions already have been made to science that the world is justified in looking there for great and outstanding results in the near future.

The announcement of the grant by Leland Stanford University states that the income from a sum of about $300,000 is to be employed in the establishment of the Daniel Guggenheim Experimental Laboratory of Aerodynamics and Aeronautic Engineering. The present aerodynamics laboratory, in which experiments have been conducted for ten years, will be developed and improved with the addition of equipment for tests of planes and will be housed in a commodious brick and concrete structure. In addition Stanford University will establish a full course for the training of young men in aeronautical engineering. This course will be an extension of the present work of the University in aeronautics into a complete and well organized six-year course.

To the California Institute of Technology a grant of $200,000 has been made for the establishment of laboratories and $10,000

will be granted annually for a period of ten years for the furtherance of its work in aeronautics.

In a telegram to Dr. R. A. Millikan, President of the California Institute of Technology, Mr. Guggenheim said:

> This gift is made also as a tribute to the distinguished work in science and education of yourself and associates, and because of our belief that you are developing in Southern California an institution which is destined to make very great contributions to the progress not only of our own country but of the whole world.

The plan of the California Institute comprises the extension of its theoretical courses in aerodynamics and hydrodynamics, and the institution of a group of practical courses conducted by the Institute's experimental staff in coöperation with the engineering staff of the Douglas Airplane Company. The plan also initiates a scheme of comprehensive research in aeronautics.

There is no doubt that these far-sighted and well advised grants to the cause of aeronautics will have a far-reaching and enduring effect on the development of American aviation.

Civil Aviation Meeting at Philadelphia

DURING the National Air Race Week at Philadelphia, September 4 to 11, a very timely meeting on Civil Aviation was held on the evening of September 7 under the joint auspices of the Aeronautic Division and the Philadelphia Local Section of The American Society of Mechanical Engineers, the Engineers' Club of Philadelphia, and the Aero Club of Pennsylvania. Preceding the technical papers was a dinner at the Bellevue-Stratford Hotel with Hollinshead N. Taylor of Philadelphia presiding. The distinguished and representative body of men at the speakers' table included the Hon. Edward P. Warner, Assistant Secretary of the Navy and member of the A.S.M.E., and the Hon. William P. MacCracken, Assistant Secretary of the Department of Commerce. The Hon. F. Trubee Davison, Assistant Secretary of the War Department, sent his regrets at being unable to attend under pressure of his new official duties.

In introducing the two secretaries, Mr. Taylor pointed out that it was a remarkable fact that three such young men as Mr. Davison, Mr. Warner and Mr. MacCracken had been appointed to such important duties as the entire charge of aeronautical work in their respective departments. He thought that they were unequaled in ability and experience and that under their guidance the entire country could look forward with confidence to the utmost encouragement and support of commercial aviation on the part of the Government.

The Hon. Edward P. Warner in his speech discussed the work of the Navy in the development of new types of aircraft. He pointed out that the work of the Navy had an important bearing on the development of commercial aeronautics and pledged his department to do everything consistent with its duties to further commercial activities in every possible way.

The Hon. William P. MacCracken discussed the new aviation work of the Department of Commerce. This work fell naturally into three subdivisions. First, there was the provision of navigational aids to the air-line operators of the country. These aids comprised lighting of the great airways, the provision for meteorological reports, and the direction of aircraft by radio beacons. The Department of Commerce was rapidly setting up the lighting systems which were indispensable to night flying, had placed contracts for beacons, and had already surveyed the most important routes for which lighting was contemplated. Mr. MacCracken thought that another important function of his Department was the fostering of commercial air traffic, and to this end a survey was under way which would provide air-line operators with much useful information as to business obtainable and the directions in which they might best turn their energies in securing business. Mr. MacCracken then spoke of Air Regulation, which comprised the licensing of planes and pilots and th determination of the rules of air traffic. The Assistant Secretary's plan was to make these regulations as concise, as clear, as unbureaucratic and useful as possible. He announced that a series of conferences were to be held in Washington in which the Department would seek the advice and criticisms of the representative men in every phase of commercial aeronautics, whether construction or operation.

Lester D. Gardner[1] made a brilliant and fascinating speech covering his experiences abroad in a trip round Europe by air. Mr. Gardner had flown over 21,000 miles in less than 240 hours. He had flown behind 110 engines, with 55 pilots of 15 different nationalities and over 26 countries. Not a single engine or plane failure had been experienced in his travels and this fact had impressed him with the remarkable development from a point of view of safety that the airplane had already attained. Monoplanes seemed to have an advantage over biplanes in European practice at the moment; three-engined planes were used in many instances and metal construction was very frequently employed. What had struck Mr. Gardner most forcibly on his travels was the extraordinary manner in which aircraft had brought countries closer together; air travel seemed to change all previous geographical conceptions.

Archibald Black[2] then presented a paper on Civil Aviation in the United States, which will be reported more fully in a subsequent issue of MECHANICAL ENGINEERING. Mr. Black presented a statistical and up-to-date review of air-line operations in the United States. He showed that the annual mileage of air-transport routes in the United States already led the world, with British mileage a long way behind, followed next by the German lines and then by the French. The timely passage of a Federal law authorizing the Postmaster General to contract for the carrying of domestic mail by air had greatly aided this development. He pointed out that on United States air lines the Liberty 400-hp. engine was being replaced by more modern types. In the matter of reliability and performance remarkable results had been attained recently. Several companies had records of more than 95 per cent perfect flying, and one or two had carried out their schedules with 100 per cent records.

Dr. J. H. Dellinger[3] presented a paper of extreme interest on Applications of Radio to Air Navigation. This also will be published in a later issue of MECHANICAL ENGINEERING. He discussed authoritatively the applications of radio to aircraft in regard to communication between plane and ground. The problem of the directive beacon had already been solved to a large extent and such beacons should prove invaluable in fog and night flying; the problems of field localizers, heights altimeters and the provision of other devices for landing in fogs were still in the experimental stage, but very promising developments were to be expected at an early date.

A Correction

ON PAGE 861 of the August issue of MECHANICAL ENGINEERING, in the last paragraph of the letter from A. R. Spicacci, 1500 r.p.m. should read 15,000 r.p.m.

A steam-turbine generator unit rated at 208,000 kw. or nearly 280,000 hp., about three times as large as any of the giants in service today and nearly half again as large as any under construction anywhere in the world, is being manufactured by the General Electric Company at Schenectady, N. Y., as the first unit for the world's newest and largest electric generating station, that of the State Line Generating Company on the Lake Michigan shore, on the Indiana side of the Indiana-Illinois state line.

The turbine-generator will be unique in many respects. Not only will it be the largest, but it will incorporate the largest 1800 r.p.m. generator ever constructed, it will be the first to use live steam for reheating, and it will be the first turbo-generator to generate current at 18,000 volts.

The 208,000-kw. turbine-generator unit includes a high-pressure element and two low-pressure ones, so connected that the sections can be operated independently, should such be desired. Steam is admitted to the high-pressure, 76,000-kw. element at 600-lb. pressure and 730 deg. fahr. From there, at reduced pressure and temperature, the steam passes to a reheater using live steam. After being raised to a temperature of 500 deg. fahr. by the live steam, it is divided and passed to the two other turbines, each rated at 66,000 kw.

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[1] Publisher, *Aviation*, New York, N. Y.

[2] Garden City, N. Y., Chairman, Aeronautic Division of the A.S.M.E.

[3] Chief Physicist, Bureau of Standards, Washington, D. C.

Sixth Annual New Haven Machine Tool Exhibit Gives Evidence of Many New Developments in the Industry

THE attention of a great many A.S.M.E. members was focused upon New Haven, Conn., from September 7 through 10. This attention centered at the Mason Laboratory of the Sheffield Scientific School of Yale University where the Sixth Annual Machine Tool Exhibit was being held.

This Exhibit, recognized as one of the outstanding annual events in the field of engineering and production, was under the sponsorship of Yale University, the New Haven Chamber of Commerce, and The American Society of Mechanical Engineers. During the Exhibit technical sessions were held under the auspices of the Machine Ship Division of the Society and important Standardization conferences were also held upon matters relating to machine tools.

From the time the doors were opened at 7 o'clock Tuesday evening until they were finally closed at 10 o'clock Friday night large crowds were in constant attendance. It is roughly estimated that 25,000 visited the show during the four days. Executives, engineers and production men representing well known concerns came from long distances to attend and several from foreign countries introduced themselves to the committee in charge Manufacturing companies in Connecticut sent bus loads of foremen and machine operating men to study the new equipment and methods.

Seventy companies exhibited their products, valued at over half-a-million dollars, and ranging in variety from huge machine tools of several tons weight down to tiny ball bearings. Only machine tools and accessories such as cutting tools, gas and electric welders, gages and precision bearings were allowed to be entered. The choice was carefully made and as a result it was a purely machine tool exhibit of the highest class. About eighty items could strictly be classed as machine tools and most of these were running under manufacturing conditions producing commercial parts.

New Developments

Many new developments were evident this year, these tending toward saving of stock, increase of accuracy, decrease in operating effort and increase in productive speed. There were several interesting examples of machines which make parts by stamping, forging, and swaging instead of by the conventional cutting methods. Keeping pace with the improvements of these machines were machines for automatically cutting their dies and others for fastening together stamped elements by instantaneous electric welding. Flame cutting of heavy metal plates rapidly and to close specifications on most intricate designs was convincingly demonstrated by means of a motor driven pantograph machine.

The trend of machine tool design is plainly more and more toward automatic operation. This is by no means confined to screw machines but extends to chucking machines for finishing castings and forgings, to milling machines, drill presses and particularly to precision grinders.

A new internal grinder was representative of this new school of machines. It was fitted with a quick-acting self-centering chuck and went through its cycle of operations under automatic control, this extending to dressing the wheel, gaging the hole to split thousandth accuracy, and stopping the feed and withdrawing and guarding the grinding wheel upon the hole's coming to size.

Cleaner design of machine tools was also noticeable. Such accessories as drive motors, which formerly had the appearance of unwholesome excrescences, have now been merged into the ensemble so as to appear a natural part of it. The same holds true of change gear boxes, pumps for lubricating and cutting oil, the cam mechanisms of the automatic machines and the guards and gear case covers. It will be gratifying to those interested in the safety movement to know that close attention has been given to the matter of guarding dangerous mechanisms.

In many cases the controls have been centralized, both through the adoption of push-button switches and by grouping the manual controls at a strategic point. Thus for instance, all of the movements of a large radial drill may be controlled by the operator without his moving from the ideal supervisory location.

It was conclusively shown that gages and gaging systems are keeping up with the increasing demands for speed and accuracy in measurement. It was not so long ago that the micrometer measuring to one thousandth of an inch was considered the acme of accuracy and was resorted to only upon special occasions. Such micrometers are as common today in production shops as were ordinary calipers a generation ago, and are as freely used. Conventional gages, micrometers and other measuring instruments of superior accuracy were exhibited as of interest now to all mechanics. Their place as super-accurate tools was taken by delicate and powerful optical instruments working both by direct magnification and by magnified projection. By these adaptations of laboratory apparatus to the shop, an ordinary tool maker is enabled to get results far beyond the capabilities of the most skillful of craftsmen working under older systems of measurement.

Technical Sessions

The Technical Sessions this year, as usual strongly supplemented the Exhibit. The Chairmen of these sessions, Messrs. C. R. Burt, general manager of the Pratt and Whitney Co., Carl Dietz, president of the Bridgeport Brass Co., and W. F. Dixon, works manager of the Singer Sewing Machine Co. were in close touch with the subjects under consideration. Their comments were timely and interesting and they tactfully stirred up profitable discussion.

Brig.-Gen. C. L'H. Ruggles, Acting Chief of Ordnance, in his paper Sane Specifications and Intelligent Inspection, showed why extreme accuracy in ordnance material is vital by citing some disastrous results of altering specifications. At the same time he showed how departmental and industrial coöperation is now being perfected, greatly to the improvement of the national defence situation. At the same Session, F. H. Penny of the General Electric Co., outlined the progress of the individual motor drive for industrial machinery, a movement which was well illustrated in the exhibition equipment.

Dean Dexter S. Kimball of Cornell took full advantage of two excellent opportunities to raise the status of the engineering profession and to analyze a phase of its development. At a dinner Wednesday evening, September eighth, arranged in his honor, he charmed a notable group of executives, engineers and industrial leaders by his almost inspired conception of the past, the present and the future of engineering. At the Technical Session on Thursday, Executives' Day, he traced the history of machine tool design from the grotesque ornamental designs of seventy years ago to the beautiful modern designs. He "psycho-analyzed" some of the monstrosities and proved by the pleasing proportions of correctly designed machines the truth of the adage "What looks right is right." H. S. Falk's paper on The Milwaukee District Apprenticeship System, which was scheduled for this same Session, inspired much favorable editorial comment all over the country. In the absence of Mr. Falk, Mr. H. S. Hall, Director of the State Trade School at New Britain presented some interesting ideas on apprenticeship.

In his paper, Cold Press Finishing of Metal in Interchangeable Manufacture, R. V. Crane of the E. W. Bliss Co., Brooklyn, N. Y., showed how the practice of sizing forgings and castings to exact dimensions under punch presses is being developed. This method already replaces slower milling operations in some plants and promises to become a powerful factor in lowering manufacturing costs. At this Session J. E. Nicholas of the Massachusetts Institute of Technology presented the Progress Report of the A.S.M.E. Special Research Committee on Gears.

The Exhibition was as successful from the Exhibitors' standpoint as from that of the visitors. Universal praise was accorded to the management for the business-like way in which the entire affair was conducted and numerous direct sales were reported. Executives' Day, when only qualified representatives of substantial manufacturing palnts were admitted, made a particularly good impression. It was decided to hold a seventh Exhibit at New Haven next Fall.

Recent Safety Code Development

DURING the past seven years some 60 Safety Codes have been in the process of development. Of these over one-third have been completed and have been given the approval of the American Engineering Standards Committee. The codes cover a wide field of work in which over one hundred national organizations have assumed sponsorship and coöperated.

Safety in Building Construction

The Safety Code for Construction Work under the sponsorship of the National Safety Council has been in the hands of the Sectional Committee for several years. Successive drafts had been prepared, and it was hoped that the code was nearing completion, when important differences of opinion developed within the Sectional Committee. As the result of an informal conference between the principal interests concerned certain changes in objective and in administrative arrangements have been agreed to and it is expected that the first report will be completed at an early date.

When finally issued the code will be divided into two sections, one dealing with building construction and the second with general engineering construction work, such as dams, tunnels, bridges, etc. The first section will be completed and presented to the A.E.S.C. for approval before the second part is begun.

The personnel of the Sectional Committee is to be enlarged so as to make it more thoroughly representative of the industry, as the latter is at present organized. The representation of the Associated General Contractors, whose relation to this work is very important, will be increased to four. The large number of serious accidents which are occurring to those engaged in construction is giving a stimulus to this work. It is reported that in the state of Pennsylvania during the first three months of 1926 there were 25 per cent more construction accidents than in the corresponding period of 1925, which at that time was 18 per cent higher than that for 1924.

Safety Code for Amusement Parks

This code sponsored by the National Association of Amusement Parks and the National Bureau of Casualty and Surety Underwriters will include specifications for construction, operation and inspection of mechanical devices used at amusement parks. Its development was requested by the National Association of Amusement Parks. The code will contain three main parts, the first section will cover the general conditions which are applicable to all such devices and the special conditions applying to particular devices. For example, the structural care, brakes and loading of gravity, central pivot, cable driver and loose-car rides will be treated as well as fun houses, and walk-through devices. The second and third sections will deal with operation and with inspection and maintenance, respectively. A large number of organizations of national importance are officially coöperating in the formation of this code, through representation on the Sectional Committee.

Protection Against Dust Explosions

The Code of Recommended Practice for Rock Dusting of Coal Mines under sponsorship of the American Institute of Mining and Metallurgical Engineers, recently approved by the American Engineering Standards Committee, has already shown valuable results.

The National Fire Protection Association for several years has been working on regulations for preventing fire and explosions in industries which create large quantities of dust. This work was recently placed under the procedure of the American Engineering Standards Committee and its scope enlarged. The Sectional Committee which is to develop the code is sponsored jointly by the U. S. Department of Agriculture and the N.F.P.A.

Separate codes for the prevention of dust explosions in pulverized fuel systems, terminal grain elevators, flour and feed mills, sugar mills, cocoa mills, and in starch factories were reviewed by the new committee, after which they were submitted to and approved by the sponsor bodies, and received the final approval of the A.E.S.C.

Safety Code for Paper and Pulp Mills

This code prepared under the sponsorship of the National Safety Council has recently been approved by the A.E.S.C. It covers safety rules for establishments where paper or pulp or both of these are manufactured, but not including requirements which are common to numerous industries, such as guards for belts, pulleys, gears, etc., which are covered by other safety codes.

The code is divided into eight parts and deals respectively with: yards, preparation of pulpwood, preparation of rag and old paper, acid making, chemical processes of making pulp, preparation of pulp for paper machines, machine room and the finishing room. An Appendix on overhead structures and equipment, bulletin boards, loose clothing, belts and use and care of tools has been added.

The following coöperating bodies had official representation on the Sectional Committee: American Paper and Pulp Association, American Society of Mechanical Engineers, Department of Labor and Industry of Massachusetts, Industrial Commission of Wisconsin, National Association of Mutual Casualty Companies, National Workman's Compensation Service Bureau, New Jersey Department of Labor, Ohio Manufacturers Association, Ohio Society of Safety Engineers, Ontario Pulp and Paper Makers Safety Association, Pennsylvania Industrial Board, U. S. Bureau of Standards and the U. S. Public Health Service.

Gas Safety Code

The work on this Code, under the sponsorship of the American Gas Association and the Bureau of Standards, has recently been approved by the American Engineering Standards Committee. The Code is a good step forward toward increased safety in the use of gas, and embodies the necessary requirements for safe gas fitting and gas appliance installations.

In drawing up this code the Sectional Committee took special care to make the treatment clear and elementary, restricting the included subject matter to a minimum number of fundamentals. The Code treats the subject from the point of view of the industry as a whole, leaving the detailed treatment of particular subjects to separate specifications.

Mr. W. R. Addicks, senior Vice-President of the Consolidated Gas Company of New York, is Chairman of the Sectional Committee, which consists of 31 experts representing the leading American organizations interested in the work.

Color Code for Gas Masks

Work on this Code was initiated at the formal request of the National Safety Council, under the auspices of the American Engineering Standards Committee and with the coöperation of the U. S. Bureau of Mines, Chemical Warfare Service, National Safety Council and manufacturers of gas mask canisters. It is expected that the formation and use of such a Code will greatly reduce the serious results of errors in the use of this protective device. It is proposed that all canisters used as protection from a particular gas will be given a definite color.

Safety Code for Abrasive Wheels

The first revision of the Safety Code for Abrasive Wheels was recently completed by the Sectional Committee organized to formulate this Safety Code in April, 1920. The new draft was submitted to the A.E.S.C. in June, 1926 and now has its approval and designation as "American Standard."

It will be recalled that this Code, which is sponsored by Grinding Wheel Manufacturers' Association of the U. S. and Canada and the International Association of Industrial Accident Boards and Commissions, was first published in January, 1922.

In submitting the revised edition for approval the sponsors state that between 25,000 and 30,000 copies of the first edition of the Code were distributed by members of the Grinding Wheel Manufacturers' Association and that the Code is generally conceded to be the most authoritative publication on the subject. The State of New Jersey, Department of Labor, has been using officially the first edition of the code and the new edition containing the proposed amendments will be adopted as soon as approved by the A.E.S.C. The State of Pennsylvania, Department of Labor, is also contemplating the adoption of the new code as soon as it is ready.

The A.S.M.E. Research Contribution to Industry

Professional Divisions to Give Material Assistance in Expanding Program in Coming Year

ONE of the most important items in the list of tasks set by The American Society of Mechanical Engineers for the fiscal year commencing October 1, 1926 is the extension of the research program of the Society. This was made possible at the Providence Meeting of the A.S.M.E. Council in May, 1926 when in making the budget for 1926–27, an appropriation double that for 1925–26 was provided for the Standing Committee on Research to use in inaugurating new research projects and in providing more office assistance in the conduct of those projects which are already under way.

In expanding the program, the Professional Divisions will give material assistance. Each Division will canvas its field and state the problems that require the organization of special research. The Divisions will also aid in selecting personnel for special research committees and by providing the stage at sessions held under their auspices for the presentation and discussion of the reports of research committees.

The Society already has an extensive program of research built up quietly in the past few years and now including twelve active projects. The list of committee members includes nearly three hundred names. Other committees are organizing and by December at the Annual Meeting, they will be engaged actively on their problems. The methods followed by the present committees in carrying out their work are of decided interest as they show how the Society may furnish assistance in solving industry's problems. A brief statement about each Special Research Committee follows:

Lubrication. Research into the fundamental laws of lubrication is being conducted at the Bureau of Mines Experiment Station in Pittsburgh. Progress reports of this Committee's work have appeared and others are expected during the coming fall and winter.

Bearing Metals. This Committee was organized to investigate the properties of bearing metals. Efforts so far have been mainly devoted to the task of raising of funds to conduct the research necessary.

Fluid Meters. The first edition of Part I of the Report of this Committee is nearing exhaustion and a revision is being considered. The published report has proved to be a valuable reference book on fluid meters of all kinds. It treats the general types of fluid meters and discusses the methods and general physical principles involved. The work in process under this Committee's guidance is shown by the names of its Sub-Committees on Influence of Installation, Description of Flow Meters and Water Meters, Revision of Material on Pitot Tubes, Pulsating Flow and High Velocity Measurements.

Properties of Steam and Extension of the Steam Table. Work carried on at Harvard University under the auspices of this Committee provided material for an excellent paper at the 1925 Annual Meeting which contained information about the properties of steam at high temperatures which has already been of great value to industry. Research is also in progress at the Massachusetts Institute of Technology and the Bureau of Standards. This Committee holds sessions at each Annual Meeting of the Society at which the progress for the year is reported. The account of the session appears each year in the February issue of MECHANICAL ENGINEERING.

Strength of Gear Teeth. A special testing machine was designed and installed at Massachusetts Institute of Technology in 1925. The first data from this machine made public were published in the September, 1926 issue of MECHANICAL ENGINEERING in a paper on the Influence of Elasticity and Errors in Tooth Shape on Stresses in Gears. This paper was presented and discussed at the New Haven Machine Tool Exhibition on September 10, 1926. The Committee is now engaged in securing sets of gears of different pitches and different materials for subsequent tests.

Cutting and Forming of Metals. This project is being steadily developed by the efforts of the individuals who make up the Committee. The results attained by each one are systematically communicated to the rest of the Committee. Its activities are shown by the names of the Sub-Committees on Standards of Performance, Properties of Materials, Cutting Tools, Forming, Turning Processes, and Cutting Fluids. The Committee is coöperating with the Machine Shop Practice Division in arranging a session for the 1926 Annual Meeting of the Society in December at which, in addition to two papers revealing important research results, there will be progress reports from each of the above mentioned Sub-Committees. A bibliography on the general subject of cutting and of forming metals is also in the process of preparation and an early publication is expected.

Mechanical Springs. This Committee has been occupied with a determination of the present state of the art of mechanical-spring design. The splendid results attained are evidenced in papers presented before sessions at recent Spring and Annual Meetings. These papers have placed on record present knowledge about mechanical springs and the Committee is now ready to state its program of research. The success of this method of coöperative research procedure as shown by the interest aroused throughout industry commends it to other committees entering on a new field of work.

Effect of Temperature on the Properties of Metals. The American Society for Testing materials is coöperating with The American Society of Mechanical Engineers in this important study, which was placed in the hands of a joint Committee after a session of the two societies in Cleveland in 1924. Research is under way in a number of private laboratories and the results furnish the basis of discussion at the Committee meetings. Not only are special materials being procured for test but a program of tests is now in process and a progress report is expected during the current year.

Condenser Tubes. A progress report from this Committee is expected at the Annual Meeting in December.

Boiler Feedwater Studies. Seven national technical organizations are coöperating actively in this investigation. Nine Sub-Committees are functioning on Sedimentation, External Treatment, Internal Treatment, Surface Condensers, Evaporators and Deaerators, Corrosion of Boilers, Embrittlement of Metals, Municipal Water Supply in Relation to Boiler Use, Standardization of Water Analysis and Bibliography. A selection of papers, originated by this Committee and presented before the American Waterworks Association appears in this issue of MECHANICAL ENGINEERING, pages 1017 to 1024. At present plans call for progress reports from each of the Sub-Committees during the coming fall.

Boiler Furnace Refractories. Three correlated investigations are being supported by this Committee, one in the field, a second at the Bureau of Mines Ceramic Experiment Station at Columbus, Ohio and the third at the Bureau of Standards. A report by the field investigator on Refractories Service Conditions in Furnaces Burning Pittsburgh Coal on Chain Grates will appear in an early issue of MECHANICAL ENGINEERING.

Elevators. As a result of the work on the Safety Code for Elevators, prepared under the procedure of the American Engineering Standards Committee, it was evident that research on some phases of elevator design was needed and this Special Committee was appointed. Apparatus is being constructed at the Bureau of Standards for this investigation and an investigator has started work.

Committees in Process of Formation. A Research Committee on Welded Pressure Vessels is being appointed. This Committee is sponsored by the American Bureau of Welding Society to carry on this investigation.

A study of Saws and Knives for Wood Working has been endorsed by the Wood Industries Division as an important research problem. The field is being canvassed and personnel selected for this Committee.

The design of Worm Gears is to form the problem of a new Committee now being organized.

Other subjects under discussion at present include spark arresters for locomotives and substitutes for domestic woods.

Book Reviews and Library Notes

The Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

A Handbook of Safety and Accident Prevention

Handbook of Safety and Accident Prevention. By Fred G. Lange. The Engineering Magazine Co., New York, 1926. Cloth, 6 × 9 in., 512 pp., $5.

A PERSON reading this volume will appreciate at once that its author has had an active experience in safety work in the shops, and also in connection with industrial organizations and governmental agencies. The purpose of the book is defined by the author in the preface, in the following sentence: "I finally determined to attempt to bring together in one volume all of the widely scattered material which is essential to a proper understanding of the Safety First movement." The book was prepared in 1922, and valuable additions have been made in the form of supplements to bring it up to date.

The author begins by giving an outline of the building up of the safety movement in the United States, and a full discussion of accident organization and prevention methods. This latter includes a discussion of the location of accident hazards, the use of safety committees, the elimination of both physical and human accident hazards, a reasonably full discussion of some of the most typical and important physical hazards and safeguards, with illustrations, fire fighting and illumination, special conditions met in dealing with female employees, safety incentives, etc.

It includes the subject of safety rules and rule making, safety talks, bulletin boards, health hazards, medical service, first aid, occupational hazards, poisons, drowning, electric shock, and so on. It also deals with the subjects of public safety, automobile accidents, home safety, railroad safety, construction safety, teaching of safety in the schools, etc. Indeed, the whole subject is quite fully treated in the book, particularly that part relating to industry, and it is replete with useful illustrations, charts, graphs, etc.

The volume further includes copies of a large number of safety codes, or extracts therefrom, which have been drafted by governmental agencies, the American Engineering Standards Committee, and other bodies. In it is also to be found much statistical information. To those interested in safety work these statistics should be of value as indicating the status of safety in this and other countries, and also the possibilities for sane and sound safety activity.

The work is rather voluminous, necessarily, by reason of its wide scope, and it might have been condensed somewhat to advantage. It also lacks chapter headings, and, in the case of some of the material, as full correlation as might have been possible; these features are somewhat neutralized, however, by the addition of a detailed and practical index, which enables one to lay his finger upon the subject to which he may wish to refer. The book also contains detailed indexes of illustrations, charts, and forms, and quite a complete syllabus, which are helpful.

Coming at a time when accidental fatalities in this country are estimated to number annually about 70,000, and those in industry 23,000, with a correspondingly larger list of permanent mutilations and serious injuries, the volume is opportune; for that and the large amount of useful information which has been gathered into a single volume, the author is particularly to be commended.

John Price Jackson.[1]

[1] Assistant to Vice-President, General Manager, New York Edison Company. Mem. A.S.M.E. and Chairman of its Safety Committee.

Books Received in the Library

Aerostatics. By Edward P. Warner. Ronald Press Co., New York, 1926. (Ronald Aeronautic Library.) Cloth, 6 × 9 in., 112 pp., diagrams, $3.25.

A textbook based upon the first part of a course in the theory of airship design given at the Massachusetts Institute of Technology.

Aircraft Power Plants. By Edward T. Jones and others. Ronald Press Co., New York, 1926. (Ronald Aeronautic Library.) Cloth, 6 × 9 in., 208 pp., illus., diagrams, $4.25.

This book is not intended so much for those engaged in building or operating engines, as for designers of aircraft, who need to know something of the characteristics of the power plants in order to adapt them to the structures they design, and for pilots who need knowledge of the engine to operate their craft successfully. The book discusses the various types of heat engines from a thermodynamic point of view, pointing out the advantages and disadvantages of each and the factors that affect performance. Propellers are treated in the same fashion. The concluding section treats of water-ballast recovery.

Les Économies de Combustible; Combustibles Inférieurs et de Replacement. By Pierre Appell. Gauthier-Villars & Co., Paris, 1926. Paper, 6 × 8 in., 203 pp., illus., tables, 20 fr.

A concise discussion of low-grade fuels and their economic possibilities. The author treats of wood, charcoal, coke, lignite, peat, and mine, industrial, and municipal wastes, describing methods of utilizing them and their possibilities as substitutes for coal and oil.

English and American Tool Builders. By Joseph Wickham Roe. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 315 pp., illus., portraits, $4.

A reprint of the first edition with some minor corrections. Mr. Roe traces the evolution of the machine tool from the middle of the eighteenth century down to our own times, in an interesting account of the men who left a permanent impression on the industry.

Beginning with John Wilkinson and Joseph Brahman, he describes the work of Bentham, Brunel, Maudslay, the inventors of the planer, Fairbairn, Bodmer, Nasmyth, and Whitworth. In America, he traces the origin and rise of tool building and describes its spread through the country, pointing out the main lines of influence, and describing the persons and cities most closely identified with it.

Feuerfeste Baustoffe für Kammern der Kokerei-und Gaswerksöfen. By L. Litinsky. W. Knapp, Halle, 1926. Paper, 6 × 9 in., 50 pp., illus., tables, 2.80 M.

A discussion of refractory materials for coke ovens and gas ovens. The pamphlet describes the raw materials used and their properties, discusses the process of distillation as it affects the refractories and considers the relative value of the varieties of brick in use.

Handbook of Non-Ferrous Metallurgy. By Donald M. Liddell, Editor-in-chief. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 2 vols., illus., diagrams, tables, $12.

This handbook will be valued by engineers and metallurgists who wish a concise account of modern metallurgical methods,

as well as by students. Each topic has been handled by an author acquainted with it through experience.

The first volume treats of processes and materials that are common to all metallurgical operations. It contains chapters on crushing and grinding, sampling, screening, classification, concentration, dewatering, fuels, refractories, briquetting, power plants, plant materials, plant layout, and electric furnaces. In volume two a chapter is devoted to the metallurgy of each metal under discussion.

International Critical Tables of Numerical Data, Physics, Chemistry, and Technology, prepared under the auspices of the International Research Council and the National Academy of Sciences by the National Research Council of the United States of America. First edition. McGraw-Hill Book Co., New York, 1926. Cloth, 9 × 11 in., 415 pp., diagrams, $60.

This book, the result of the coöperative work of many specialists, gives the values for physical and chemical constants which they have selected as the "best" values, from the great mass of determinations recorded in scientific and technical literature before the year 1924. It selects, in each case, the value that appears most worthy of credence and makes it available readily for the scientific worker.

The need for such a reference book has long been obvious. The seeker after data, who has usually been confronted by several values, with no means of criticizing their relative accuracy, will be much relieved to have a selected figure which has the stamp of authority. The book is a necessity to every laboratory and scientific library.

In a sense, the work supplements the International Annual Tables of Constants. It removes the necessity of examining all the volumes of the latter in most cases, by giving immediately the prepared value.

Kran- und Transportanlagen für Hütten-, Hafen-, Werft-, und Werkstattbetriebe. By C. Michenfelder. Second edition. Julius Springer, Berlin, 1926. Boards, 8 × 11 in., 683 pp., illus., diagrams, 67.50 M.

An extensive descriptive treatise on modern hoisting and conveying machinery, particularly as used in smelters, rolling-mills, shipyards and harbors. The work is intended to assist in the selection of equipment rather than to aid in design and therefore the text follows the course of operations in these various industries, explaining the problem of transportation at each operation and the ways by which it can be met. The book is a useful detailed description of current German practice, illustrated with many photographs of machines and installations.

Diesel Engines: Marine—Locomotive—Stationary. By David Louis Jones. Norman W. Henley Publishing Co., New York, 1926. Cloth, 6 × 9 in., 604 pp., illus., diagrams, $5.

A manual for operators of Diesel engines, prepared by the instructor in the Diesel-engine department of the U. S. Navy Submarine School. Keeping in mind the class for which he writes, the author devotes but little time to theoretical principles, thermodynamic considerations, etc., but gives most of his attention to the actual construction and the operation of the various parts of commercial engines, to advice on operation and to descriptions of typical engines. The book should be helpful to all in charge of Diesel power plants.

Mathematics for Engineers. By Raymond W. Dull. McGraw-Hill Book Co., New York, 1926. Cloth, 5 × 8 in., 780 pp., $5.

The two sources to which the engineer turns for mathematical aid are the engineer's handbook and the mathematical textbook. The first of these, Mr. Dull says, is too concise and incomplete to be satisfactory; the second is not well adapted to use for quick reference.

The present book, prepared by a practicing engineer, appears to be primarily intended as a convenient work of reference and as a means for reviewing various topics. The entire range of mathematics ordinarily used in engineering is traversed, the examples are worked out with greater fulness than usual and the text is arranged to facilitate ready understanding of each question. Graphical solutions are included and a considerable treatment of absolute and relative errors is given.

Metallography and Heat Treatment of Iron and Steel. By Albert Sauveur. Third edition. McGraw-Hill Book Co., New York, 1926. Cloth, 8 × 11 in., 535 pp., illus., diagrams, table, $8.

As might be expected after an interval of ten years, the third edition of this well-known textbook shows many changes from the second. About fifty pages of text have been added and the text has been rearranged. Much of the work has been rewritten, with the aim to make the book a satisfactory record of present views and of current practice.

Movable Bridges, vol. 1; Superstructure. By Otis Ellis Hovey. John Wiley & Sons, New York, 1926. Cloth, 6 × 9 in., 352 pp., illus., diagrams, tables, $6.

The first volume of a treatise on the design of movable bridges and their machinery. This volume, on the superstructure, opens with a brief history of early designs. The author then discusses various types of movable bridges, giving statistical information intended to assist in determining the best type for particular conditions. The simplest and most practical methods of stress analysis are then discussed briefly, followed by a chapter on elastic deflections. Details of design are then discussed and there are chapters on rail joints, counterweights and houses for operators. Appendices give an analysis of stresses in lenticular disks and a new method for designing tread plates for the supporting and segmental girders of rolling-lift bridges.

New Leadership in Industry. By Sam A. Lewisohn. E. P. Dutton & Co., New York, 1926. Cloth, 6 × 8 in., 234 pp., $2.

Mr. Lewisohn discusses various phases of the relations between employers and employees, exposing many current fallacies concerning them. Most difficulties are due, he believes, to human nature rather than to any system, and will tend to disappear as management gives more attention to human relationships.

On the Metallurgy of Iron and Steel. By F. T. Sisco, Bengt Kjerrman, and Birger Egeberg. American Society for Steel Treating, Cleveland, Ohio, 1926. 193 pp., illus.; $1 paper cover, $2 cloth binding.

This book is a reprint of three papers presented before the American Society for Steel Treating recently, which attracted so much attention that there was a demand for their separate publication. Mr. Sisco's discussion of the metallurgy of iron and steel constitutes nearly seven-eighths of the book; Dr. Kjerrman contributes 10 pages on Swedish steel practice and Dr. Egeberg adds 5 pages on electric steel melting. The reprint will be extremely useful to any one who wishes a brief, clear, and accurate statement of the general features of iron and steel metallurgy, especially to both technical and non-technical employees of steel companies who wish to obtain a better understanding of the business they are engaged in.

Phototopography; a Manual of Photographic Surveying Methods. By Arthur Lovat Higgins. University Press, Cambridge, 1926. Cloth, 5 × 8 in., 130 pp., illus., diagrams, plates, $2.40.

The author has attempted to outline the essential principles of the operations of some of the best-known exponents of the photographic method and thus to produce a practical manual for surveyors and students.

Ports and Terminal Facilities. By Roy S. MacElwee. Second edition, enlarged. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 446 pp., illus., diagrams, $5.

The new edition of this work is actually, the author says, a new book, containing less than fifteen per cent of the original work. That portion of the older edition which dealt with the upbuilding of traffic through competitive ocean gateways now appears as a separate work entitled Port Development, while the volume before us discusses the construction and equipment of ports.

The book first discusses general matters, the characteristics of well coördinated seaports and wharf design. Equipment and arrangements for general cargo wharves and warehouses are described in detail after which attention is given to passenger terminals and facilities for handling ore, coal, liquids, and grain in bulk. The concluding chapter discusses industrial harbor development.

Le Problème Actuel du Condenseur a Surface. By A. Delas. Revue Industrielle, Paris, 1926. Paper, 5 × 8 in., 22 pp., illus., 5 fr.

Describes the results of recent researches which have increased

the efficiency of surface condensers by rearrangement of the condenser tubes. These rearrangements have made it possible, at the Gennevilliers power plant, to suppress one-fourth of the tubes in certain of its condensers.

Propriétés Physiques des Vapeurs de Pétrole et les Lois de Leur Écoulement. By Jean Rey. Dunod, Paris, 1925. Paper, 6 × 9 in., 251 pp., diagrams, plates, tables, 8.50 fr.

The author has found it necessary, in connection with his professional work, to undertake an extensive investigation of the physical properties of kerosene. In this memoir he presents the results of his researches.

In part one the numerical values he has obtained are used to determine approximately the law of variation, with the temperature or pressure, of the physical properties of kerosene; vapor tension, heat of vaporization, liquid density, specific heat, etc. The second part describes the apparatus used in the researches, and the application of the burners invented by the author to boilers and lighthouses.

Radioactivity. By George Hevesy and Fritz Paneth; translated by Robert W. Lawson. Oxford University Press, London and New York, 1926. Cloth, 6 × 9 in., 252 pp., illus., diagrams, tables, 15 s.

Hevesy and Paneth's Radioactivity first appeared in the German language in 1923. Translations into Russian and Hungarian were published in 1924 and 1925, and now comes the present English version. This last is not a literal translation of the original work, but is essentially a new edition, for the authors have incorporated in it the results of scientific advances since the German edition appeared and have extended the bibliographic references up to 1925.

The book differs from the majority of those on the subject by being intended specifically for use as a textbook, a work which will give those having no preliminary knowledge of radioactivity an insight into the science at first hand. The subject matter is arranged from the didactic point of view, somewhat as is done in textbooks of physics and chemistry, the historical development of the subject being separated and outlined late in the book.

Ratio Chart in Business. By Percy A. Bivins. Codex Book Co., New York, 1926. Cloth, 6 × 8 in., 177 pp., charts, $3.

A clear, detailed description of the methods of making ratio or logarithmic charts and thorough explanation of many of their applications in industry and business. The author treats the subject in simple language, readily understood by those unfamiliar with the subject, and the book should do much to popularize this valuable method.

Refining Metals Electrically. By Larry J. Barton. Penton Publishing Co., Cleveland, 1926. Cloth, 6 × 9 in., 414 pp., illus., tables, $6.

A treatise on electric-furnace practice in the foundry. The author discusses theoretical matters concisely, but devotes most attention to practical questions, such as the cost of electric melting, the choice of a furnace, preparing linings and making the various kinds of steel and iron. A selected bibliography is included.

Les Réserves d'Énergie. By M. Rigaud. Gauthier-Villars & Co., Paris, 1926. Paper, 5 × 8 in., 295 pp., 30 fr.

Discusses, from a broad viewpoint, the possible sources of energy and present utilization of them. Beginning with the kinetic energy of the earth and the utilization of tidal power, the author then considers the internal energy of the earth. Radiant energy from the sun is discussed, with its indirect utilization by winds and direct utilization by falling water. Turning then to mineral fuels, the winning and use of coal and oil are treated.

Science of Flight and Its Practical Application, vol. 1; Airships and Kite Balloons. By P. H. Sumner. Crosby Lockwood & Son, London, 1926. Cloth, 6 × 9 in., 168 pp., illus., diagrams, tables, 16 s.

After an introductory chapter on the British air policy, Captain Sumner takes up successively the principles of aerostatics, the general construction of the dirigible, the airship in flight, the types of airships and their performances, and kite balloons. The book, which is the first of two volumes on the general subject of flight, is devoted to buoyant airships. It is based on the author's long experience in airship construction in the Air Ministry.

Stainless Iron and Steel. By J. H. G. Monypenny. John Wiley & Sons, New York, 1926. Cloth, 6 × 9 in., 304 pp., illus., diagrams, tables $6.

The author, chief of the research laboratory, Brown Bayley's Steel Works, Sheffield, gives a detailed account of the properties of the various grades of stainless steel and of its microstructural characteristics. He gives particular attention to the range of diverse materials included in the term, and to the influence of variations in composition and treatment on their properties, with the object of aiding users in the selection of suitable grades.

Statik für Baugewerkschulen und Baugewerksmeister, vol. 2; Festigkeitslehre. By Karl Zillich. Ninth edition. Wilhelm Ernst & Sohn, Berlin, 1926. Boards, 5 × 7 in., 157 pp., diagrams, tables, 3.40 M.

A concise manual on the strength of structural materials, intended as a textbook and a ready reference book.

Steel Structures; Stresses in Simple Structures. By Leonard C. Urquhart and Charles E. O'Rourke. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 278 pp., diagrams, tables, $3.50.

This book aims to present clearly the fundamentals of stress calculation in simple structures, without confusing the student by complicating the discussion by frequent references to the economics of design. The latter topic is best treated later, they believe, in connection with design. The text is confined to simple structures and contains both graphical and analytical analyses, except in cases where the advantage of one method is very marked. Both methods are illustrated by numerical problems.

Tables Annulles de Constantes et Donnees Numériques de Chimie, de Physique et de Technologie, vol. 5, part 2, 1917–1922. Published by l'Union de Chimie pure et appliqué. Gauthier-Villars & Co., Paris; Cambridge University Press, Cambridge, England; University of Chicago Press, Chicago, 1926. Cloth, 9 × 11 in., 1130 pp., 11×9 in., $25, for Parts 1 and 2.

A new volume of this indispensable collection of chemical and physical data, containing tables showing those recorded during the years 1917–1921. With the publication of this volume, the interruption caused by the war has been made up. A volume covering the years 1924 and 1925 will probably appear early next year, and it is the hope of the Committee soon to make the publication again an annual.

Transport Aviation. By Archibald Black. Simmons-Boardman Publishing Co., New York, 1926. Cloth, 6 × 9 in., 245 pp., illus., tables, $3.

A discussion of the various problems connected with commercial aviation. The author describes present developments here and abroad and studies the possibilities of the airplane as a means of transportation. He discusses the influence of design upon the cost of operation, general requirements of airplanes for commercial use, the design of passenger and freight airplanes, airways, landing fields and the organization of air lines. Cost data are scattered through the book.

Über die Wahl Eines Gaswerksofensystems. By L. Litinsky. William Knapp, Halle, 1926. Paper, 7 × 10 in., 29 pp., illus., 1.50 r.m.

In selecting the generators for a gas works the problem is to choose the type that will produce gas at the lowest cost per cubic foot, but many factors enter into the decision as to what constitutes the most economical equipment. The present pamphlet analyzes the various alternatives before the designer and points out the relative merits of each.

Water Rates and Steam Consumption of Marine Machinery. By H. E. Brelsford and E. A. Stevens. Simmons-Boardman Publishing Co., New York, 1926. Cloth, 5 × 8 in., 169 pp., graphs, $2.

The authors are respectively the chief and the senior engineer of the Technical Section of the Emergency Fleet Corporation. While compiling standard performance curves for the ships of the Corporation they encountered great difficulty in establishing the fuel rates, which depend largely upon the water rates. A result of their experience is the present book, which presents a method for obtaining water rates and steam consumption with a reasonable degree of accuracy. The book discusses reciprocating engines, geared turbines and the auxiliary machines usual on ships.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCIDENT PREVENTION

Mines. Statistics for Accident Prevention in American Mines, W. W. Adams. Min. Congress Jl., vol. 12, no. 8, Aug. 1926, pp. 574–575. Causes of accidents about 25 per cent mechanical and 75 per cent human; hence greatest progress in reducing accidents depends upon human factor; statistical records make it possible to arouse competitive spirit; uniformity of methods in gathering statistics important.

AERONAUTICAL INSTRUMENTS

Inclinometers. The Problem of Inclinometers in Aviation (Ueber die Frage der Neigungsmessung im Flugbetrieb), H. List. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 27, July 3, 1926, pp. 921–923, 7 figs. Discusses two classes of gyro instruments for measurement of incline, namely, instruments of gyro pendulum type and those of so-called steering gyroscope.

AERONAUTICS

Legislation and Conventions. Aeronautics in Italian Law and International Convention (L'aeronautica nella legge italiana e nella convenzione internazionale), V. Mori. Rivista Marittima (supp.), June 1926, pp. 1–165. Summary of Italian laws, international conventions, regulations, etc., governing military and civil aeronautics, including laws of air and sea, aerial navigation and transportation, salvage and assistance in distress, tariffs, airports, etc.

AIR

Pollution. Air-Pollution, J. B. C. Kershaw. Combustion, vol. 15, no 2, Aug. 1926, pp. 103–105. Notes upon recent progress in Great Britain in relation to air sanitation.

AIR COMPRESSORS

Hydraulic. An Experimental Investigation of Hydraulic Air Compression, P. F. Mumford. Mech. Eng., vol. 48, no. 9, Sept. 1926, p. 888. Describes apparatus working on jet or injector principle, which is supposed to supply field where Taylor system is applicable.

Intake-Valve Control. Compressor for Air Brake System Has Intake Valve Control, W. L. Carver. Automotive Industries, vol 55, no. 2, July 8, 1926, pp. 52–54, 4 figs. Valve held in locked position when desired predetermined pressure has been built up; prevents noise of fluttering; other interesting features found in Christensen system

AIRCRAFT

German Exhibition. A Stroll through the Aeronautic Exhibition of the W G. L. (Ein Rundgang durch die Luftfahrt-Ausstellung der WGL.), G. Manigold. Zeit. für Flugtechnik u Motorluftschiffahrt, vol. 17, nos. 11–12, June 28, 1926, pp. 229–262, 46 figs. Description of exhibits at exposition held in Dusseldorf by Scientific Association for Aeronautics (W.G.L.).

AIRPLANE ENGINES

Air-Cooled vs. Water-Cooled. Financial Comparison of Air-Cooled and Water-Cooled Airplane Engines (Moteurs d'avions à refroidissement par l'air ou par l'eau), J. A. Lefranc. Nature (Paris), no. 2727, July 10, 1926, pp. 20–24, 4 figs. Operating expenses of both types are practically same, but in case of 400-hp. engines the air-cooled one is 200 kg. lighter and will carry that extra weight of freight 160,000 km. in 1000 hr. of flight.

American Development. Modern American Aircraft Engine Development, C. L. Lawrence. Roy. Aeronautical Soc.—Jl., vol. 30, no. 187, July 1926, pp. 405–424 and (discussion) 425–433, 20 figs. Calls attention to interesting and unusual features of American engines and discusses considerations which have led to designs in question.

Carburetors. The Working of Airplane-Engine Carburetors (Die Arbeitsweise der Flugmotorenvergaser), Wimplinger. Motorwagen, vol. 29, no. 17, June 20, 1926, pp. 375–377, 7 figs. Enumerate special requirements for this class of service.

Exhaust Valves, Steel for. Influence of Working Temperature on the Selection of Metals for Airplane Engines—Application to Exhaust Valves (Influence de la zone thermique de travail sur la selection des métaux pour moteurs d'aviation. Application aux soupapes d'échappement), Grard. Revue de Métallurgie, vol. 23, no. 6, June 1926, pp. 317–330, 3 figs. Analysis of operating conditions of exhaust valves; metallurgical discussion of problem; tests of a chrome-silicon steel (Cr, 12 per cent, Si, 2.5 to 3 per cent) meeting requirements.

History of. History of the Aeronautical Engine, C. F. Taylor. Aviation, vol. 21, no. 7, Aug. 16, 1926, pp. 284–286, 4 figs. Points out that basic features remain almost unchanged through development years.

Jupiter. The Bristol Jupiter Series VI, Aeroplane, vol. 31, no. 2, July 14, 1926, pp. 76–80, 8 figs. Bristol Jupiter VI 9-cylinder radial air-cooled airplane motor.

AIRPLANE PROPELLERS

Haw. The Haw Propeller (Die "Haw"-Metall-Luftschraube), G. Manigold. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 10, May 28, 1926, pp. 211–213, 4 figs. Details of composite propeller; each wing has skeleton made out of 2 nickel-chromium-steel rods which are anchored to nickel-chromium-steel hub; on these rods is fastened a ribbed silumin covering in such manner that it is under slight initial stress, which is relieved in flight by centrifugal force; great torsional rigidity is secured; ribs are covered with sheet of light metal.

Tip Speeds. Airscrew Tip Speeds, R. K. Pierson. Flight, vol. 18, no. 30, July 29, 1926, pp. 464c–464e, 1 fig. Table showing relation between air-screw diameter, efficiency, tip speed, and forward speed for various engines, and curves showing decrease of efficiency with increase of tip speed.

AIRPLANES

Airfoils. On the Drag of an Aerofoil for Two-Dimensional Flow, H. Lamb. Roy. Soc.—Proc., vol. 3, no. A 759, July 2, 1926, pp. 592–603, 8 figs. Profile drag of airfoil of infinite span.

Albatros. Albatros Passenger and Cargo Airplanes (Albatros-Verkehrs- und Lasten-Flugzeug L 72 a), G. Lachmann. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 10, May 28, 1926, pp. 200–202, 12 figs. Data of a biplane of 42-ft. span for carrying useful load of 880 lb.; engine, 220 hp.; maximum horizontal speed, 110 m.p.h.

Armstrong-Whitworth. The Armstrong-Whitworth "Argosy." Flight, vol. 18, no. 31, Aug. 5, 1926, pp. 473–476, 12 figs. Three-engined passenger carrier is large biplane with three Armstrong Siddeley Jaguar engines, and mainly characterized by considerable forward projection of fuselage in front of wings.

Characteristic Numbers. Characteristic Numbers (Vergleichsgrössen zur Flugzeugstatistik), E. Everling. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 10, May 28, 1926, pp. 202–207, 1 fig. To judge performances of an existing airplane or form opinion of what might be expected of a new plane, following characteristic numbers are proposed: speed, distance, and altitude coefficients; mathematically these coefficients can be very simply defined; all have propeller efficiency as numerator; manner in which relations can be derived from structural data and from performance tests; presents diagrams with aid of which computation is made easier. See brief translated abstract in Automotive Abstracts, vol. 4, no. 7, July 20, 1926, p. 205.

Flying Boats. See FLYING BOATS.

Fuel Tanks. The Curtiss Duralumin Fuel Tank. Aviation, vol. 21, no. 6, Aug. 9, 1926, p. 250. Fuel tank which combines light weight with strength and overcomes maintenance and repair troubles.

Gliders. The Sixth Rhoen Glider Competition, 1925 (Der 6. Rhönsegelflug, 1925), R. Eisenlohr. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 2, Jan. 28, 1926, pp. 28–34, 14 figs. Illustrated descriptions of the various gliders entered.

Huff-Daland Bomber. The Huff Daland Bomber XLB-1. Aviation, vol. 21, no. 6, Aug. 9, 1926, pp. 252 and 254, 8 figs. One of largest single-engine light bombers in existence; it has all-metal fuselage of welded steel tube constructed in one unit from nose to tail and involving use of no wire bracing whatsoever; equipped with Packard 2A-2500, 800-hp. water-cooled engine.

Limits and Possibilities. Limitations and Possibilities (Grenzen), R. Vogt. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 10, May 28, 1926, pp. 207–210, 1 fig. Author visualizes ideal airplane capable of remaining over 52 hours in air with real pay load and traveling 5700 miles; these conclusions are based on detailed mathematical elucidations. See brief translated abstract in Automotive Abstracts, vol. 4, no. 7, July 20, 1925, pp. 204–205.

Load-Carrying. A Giant Load-Carrying Aeroplane. Automobile Engr., vol. 16, no. 217, July 1926, p. 259, 1 fig. Model of proposed design of 20-ton pay load equipped with 10 engines developing 1000 hp. each.

Speed. The Cost of Speed in Airplane Transportation (Le prix de la vitesse dans les avions de transport), P. Grimault. Aéronautique, vol. 8, no. 86, July 1926, pp. 233–236, 1 fig. Starts from quantity of gasoline used per unit of weight per unit of distance and develops formulas for calculating most economic weight, speed, power, dimensions, etc.; shows that speed is not incompatible with economy.

Strut and Propeller Sections, Bending Strength. A Practical Formula for Calculating the Bending Strength in Difficult Cases (Eine praktische Formel für Berechnung der Biegungsfestigkeit in schwierigen Fällen), Otto Steinitz. Praktischer Maschinen-Konstrukteur, vol. 59, no. 21–22, May 29, 1926, pp. 214–216, 12 figs. Simplified method of calculating bending strength of streamline sections of struts and of propellers.

Wings. On the Slotted Wing Again. Aeroplane, vol. 31, no. 4, July 28, 1926, pp. 117–118 and 120, 7 figs. In author's belief, with proper development of slot idea, airplane of normal type can be made to do anything which is done by Hill tailless machine and Autogiro, while retaining speed and climb and weight-lifting ability of normal airplane.

AIRSHIPS

Pressure Distribution. Pressure Distribution on the C-7 Airship, J. W. Crowley, Jr., and S. J. DeFrance. Nat. Advisory Committee for Aeronautics—Report, no. 223, 1926, pp. 3–41, 39 figs. Investigation to determine aerodynamic pressure distribution encountered on "C"-class airship in flight; method of testing consisted of measuring pressures by means of orifices located at desired points connected to tubes of multiple liquid manometer; it is concluded that pressures set up by bump are larger than those obtained in manœuvering.

Note.—The abbreviations used in indexing are as follows:
Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

ALLOYS

Bronzes. See BRONZES.

ALUMINUM

Compression Tests. Compression Tests with Aluminum Cubes (Druckversuche an Aluminiumwürfeln), G. Sachs and E. Schiebold. Mitteilungen aus dem Materialprüfungsamt, no. 1, 1926, pp. 1–8, 15 figs. Investigation to establish changes in resistance to deformation of 99.6 per cent aluminum cubes under X-rays, both cast and annealed; changes in microstructure; liberating internal stresses by annealing, etc.

APPRENTICES, TRAINING OF

Building Contractors. The Building Contractor and Apprenticeship. Am. Contractor, vol. 47, no. 30, July 24, 1926, pp. 18–19. Responsibility of promoting apprenticeship lies jointly with vocation school and building industry.

Coöperative System. The District Apprenticeship System, H. S. Falk. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 885–887. Successful coöperative system of training for communities of large and small shops; each shop bears its share of responsibility.

ASH HANDLING

Hydraulic Removal. The Hydraulic Removal of Ashes in Steam Plants (Die hydraulische Ascheberseitigung in Dampfkraftwerken), H. Hermanns. Wärme, vol. 49, no. 26, June 25, 1926, pp. 458–462, 8 figs. Difficulty of ash removal increases almost with square of grate area, hence it is necessary to separate completely stoking and ash-removal services where large boilers are concerned; describes Rothstein low-pressure hydraulic system which is simple and economical in operation, subject to little wear, and completely eliminates dust and dirt in ash basement; water is supplied at pressure of $^1/_2$-in., water gage, and weight required is from 6 to 10 times that of ashes removed; data concerning typical installations. See translated abstract in Power Engr., vol. 21, no. 245, Aug. 1926, p. 313.

AUTOMOBILE ENGINES

Manufacture. Motor Plant Steps Up Production, L. S. Love. Iron Age, vol. 118, no. 8, Aug. 19, 1926, pp. 473–476, 9 figs. Changes in equipment reduce time for machining flywheels, clutch disks and other parts; heat-treating furnaces equipped with loading device. Practice at Plainfield, N. J., plant of Int. Motor Co., in manufacture of Mack bus engines.

Overhauling. Engine Overhauling in Fleet Maintenance, W. S. Penfield. Soc. Automotive Engrs.—Jl., vol. 19, no. 2, Aug. 1926, pp. 183–185. Author lists operations in their sequence as dismantling, cleaning, inspection, estimating, assembling, running-in, testing, and final inspection.

Power Losses. Engine Power Losses. Autocar, vol. 57, no. 1602, July 16, 1926, pp. 89–90, 2 figs. Ingenious testing plant designed to show how much engine power is absorbed internally by drawing moving parts.

Supercharging. Supercharging. Automobile Engr., vol. 16, no. 218, Aug. 1926, pp. 278–284, 5 figs. Thermal study of its application to racing; application of Stodola's gas-entropy table; power absorbed by supercharger and power balance of supercharged engines; characteristic properties of supercharged engines.

AUTOMOBILE FUELS

Coal, from. The Production of Gasoline Substitutes and Solvents, R. T. Elworthy. Gas Age-Rec., vol. 58, no. 5, July 31, 1926, pp. 137–138 and 146. Discusses three main groups of processes for obtaining substitute motor fuels from coal, namely: recovery of benzol, ethyl alcohol and light oils in either high or low-temperature carbonization processes; conversion of certain types of coals into oils by hydrogenation at high pressures by Bergius process; gasification of coal and subsequent conversion of gases to liquids by Badische, Fisher, or Patart process.

Detonation Temperatures. Detonation Temperatures, R. W. Fenning. Auotmobile Engr., vol. 16, no. 218, Aug. 1926, pp. 296–297, 1 fig. Considers knock occurring with mixtures of normal strength, and gives results of recent experiments using pentane and heptane. Communicated from Nat. Physical Laboratory.

Gasoline. See GASOLINE.

Volatility. Volatility Tests for Automobile Fuels, T. S. Sligh, Jr. Soc. Automotive Engrs.—Jl., vol. 19, no. 2, Aug. 1926, pp. 151–161, 11 figs. Review of previous methods of arriving at fuel volatility; new method is equilibrium distillation of fuel in presence of known weight of air; fuel is supplied at predetermined rate by displacement from reservoir by fall of clock-controlled cylinder, and flows into long metal helix immersed in bath at temperature of test; data for five fuels of varied characteristics.

AUTOMOBILE MANUFACTURING PLANTS

Citroën. The Works of André Citroën. Automobile Engr., vol. 16, no. 217, July 1926, pp. 248–251, 9 figs. Résumé of more interesting methods in Paris factory.

Essex Bodies, for. New Essex All-Steel Bodies Produced by Revolutionary Methods, J. E. Schipper. Automotive Industries, vol. 55, no. 4, July 22, 1926, pp. 126–130, 15 figs. Jigs entirely dispensed with at new $10,000,000 Detroit plant; parts riveted and bolted together after being formed and hole-punched on press dies; assembly work done on moving conveyors.

France. The Manufacture of the 15.9-h.p. Hotchkiss Car. Machy. (Lond.), vol. 28, nos. 710, 711, 712, 713, 714, 715 and 716, May 20, 27, June 3, 10, 17, 24 and 30, 1926, pp. 161–170, 189–197, 221–224, 253–262, 285–297, 317–321 and 357–360, 87 figs. Methods and equipment of new Hotchkiss factory at St. Denis, France; equipped for production of complete chassis under one roof.

AUTOMOBILES

Brakes. The B.K. Vacuum Brake. Motor Transport, vol. 43, no. 1, 113, July 12, 1926, pp. 61–62, 2 figs. Description of B.K. booster brake; quick action is obtained by destroying instead of creating vacuum in operating cylinder.

Brakes, Four-Wheel. Four-Wheel Brakes—The Sought and the Attainable in (Vierradbremsen—Erstrebtes und Erreichbares), H. Schrön. Motorwagen, vol. 29, no. 16, June 10, 1926, pp. 347–357, 34 figs. Description of various types; action of parts; simplification; standardization.

Front Axles. Designing Front Axle Ends to Support Braking Stresses, P. M. Heldt. Automotive Industries, vol. 55, no. 6, Aug. 5, 1926, pp. 212–216, 7 figs. Ordinary front axle has not sufficient torsional rigidity to resist stresses imposed by application of front-wheel brakes and solid section is advocated instead of I-section.

Gear Shifts. Unrestricted Pre-Selection Feature of New Mechanical Gear Shift. Automotive Industries, vol. 55, no. 7, Aug. 12, 1926, pp. 248–250, 3 figs. Gears unmeshed and meshed positively during downward motion of clutch pedal; springs are not relied upon for shifting.

Vacuum Operates Gear Shifter. Automotive Industries, vol. 55, no. 8, Aug. 19, 1926, p. 304, 2 figs. Vacuum of inlet manifold is being used to shift gears in Craig automatic gear shifter; replacement unit featured by preselection of speeds and ease of control.

Headlights. Non-Dazzle Automobile Headlight (Die Abblendung der Scheinwerfer bei Kraftfahrzeugen), M. Anschütz. Elektrotechnik u. Maschinenbau (Lichttechnik), vol. 44, no. 17, Apr. 25, 1926, pp. 43–45, 4 figs. Describes headlight with depressible beam, depending on use of double-filament lamp, and foot switch which is used for changing from one beam to other.

Light. What is a European Light Car? P. M. Heldt. Automotive Industries, vol. 55, no. 7, Aug. 12, 1926, pp. 252–254, 2 figs. Analysis of 76 British models sheds new light on question of what constitutes European type of light car.

Light Metals for. Lightening Automobiles by Use of Light Metals (Allègement des véhicules automobiles par l'emploi de métaux légers), A. Banlier. Industrie des Voies Ferrées et des Transport Automobiles, vol. 20, no. 233, May 1926, pp. 225–231. Aluminum and magnesium and their alloys, properties and composition; their use in automobile and omnibus construction, and tests carried out with alpax metal construction, resulting in 10.8 per cent reduction of weight.

Locks. Coincidental Locks, C. M. Manly and C. B. Veal. Soc. Automotive Engrs.—Jl., vol. 19, no. 2, Aug. 1926, pp. 127–144, 36 figs. Discusses locks as theft retardants; coincidental lock was developed to take advantage of fact that drivers almost universally turn off ignition switch when leaving car unattended; it makes locking and ignition functions interrelated so that it is impossible to open ignition circuit without either previously or simultaneously locking car; illustrated description of various types represented among locks now classified as Group 1.

Steering Mechanisms. Duplicate Steering. Autocar, vol. 57, no. 1602, July 16, 1926, pp. 108–109, 2 figs. Novel layout which is claimed to prevent "shimmy" being set up by wheel wobble.

AVIATION

Aerial Navigation. Aerial Navigation, B. Jones. Soc. Automotive Engrs.—Jl., vol. 19, no. 2, Aug. 1926, pp. 162–164. Points out that navigation is of prime importance in aircraft operation, as it implies flying most direct course and selecting altitude that has most favorable meteorological conditions; points out some peculiarities of navigation on polar flights in spring of 1926; how ship and airplane drift differs.

Air-Mail Service. The Air Mail, C. C. Gove. Engrs. and Eng., vol. 43, no. 7, July 15, 1926, pp. 181–184. Airplane mail transportation; night flying; lighting of airways; mileage records; contract air-mail service; future development.

Civil. Ten Years of Civil Aviation, E. D. Osborn. Aviation, vol. 21, no. 5, Aug. 2, 1926, pp. 214 and 216, 2 figs. Review of American progress; causes of growth; war-surplus equipment; air-mail and private air lines; future prospects.

Commercial. Progress in Air Transportation, W. B. Stout. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 1–5, 2 figs. Points out how commercial flying can be made as safe as other means of transportation, and success of air transportation industry in future will depend largely upon ability of builders and users of commercial planes to demonstrate safety of flying.

Military. A History of the U. S. Army Air Corps. Aviation, vol. 21, no. 5, Aug. 2, 1926, pp. 170–173, 6 figs. Retracing story of military aviation from its inception.

Naval. A History of U. S. Naval Aviation. Aviation, vol. 21, no. 5, Aug. 2, 1926, pp. 176–179, 3 figs. Aviation in navy from its earliest days.

B

BEARINGS

High-Speed. Design of High Speed Bearings, C. R. Alden. Abrasive Industries, vol. 7, no. 8, Aug. 1926, pp. 251–253, 6 figs. Internal grinding spindles, operated at high rotative speeds, call for extremely accurate anti-friction bearings.

BEARINGS, BALL

Single-Row. The Design of Single Row Ball Bearings, A. Palmgren. Engineering, vol. 122, no. 3159, July 30, 1926, pp. 127–129, 6 figs. Discusses two types of groove bearings, both developed from Stribeck type, but which present different features; one is provided with filling slot in order to facilitate fitting of largest possible number of balls, whereas other has no filling slot and thus operates with reduced number of balls; results of calculations show clearly that bearing without filling slot (and which, on account of this fact, operates with reduced number of balls) is in no way inferior, but in several respects superior to bearing type with largest number of balls and filling slot.

BEARINGS, ROLLER

Rolling Stock. Modern Roller Bearings for Rolling-Stock Axles (Moderne Wälzlagerachsbüchsen für Schienenfahrzeuge), Theobald. Verkehrstechnik, vol. 43, nos. 23, 24 and 25, June 4, 11 and 18, 1926, pp. 364–366, 384–386 and 402–404, 22 figs. Types shown at Munich Exposition of Transportation, including those by Krupp, Fichtel & Sachs, Fries & Höpflinger, S K F, Riebe, Fischer, G. & J. Jaeger; journal bearings and lubrication.

BELTING

Conveyor. Conveyor Belting in Production of Silica Sand, R. A. Goodwin. Belting, vol. 29, no. 1, July 1926, pp. 19–21, 3 figs. Rubber belting with heavy cover is found most economical for handling materials of this kind.

Selection. The Choice of Belting. Power Engr., vol. 21, no. 245, Aug. 1926, pp. 296–297. Survey of belting characteristics and requirements; author concludes that leather is most satisfactory belting.

Velocity, Study of. Experimental Methods for Investigating the Working of Belts (sur une méthode expérimentale d'étude du fonctionnement des courroies), R. Swyngedauw. Académie des Sciences—Comptes Rendus, vol. 182, no. 7, Feb. 15, 1926, pp. 441–443. Each element of a belt when running is subjected to variations of length which are related to acting tensions; author describes two stroboscopic methods for study of belt velocity at any particular point: (1) Based on comparison of speed of point of belt with that of pulley; (2) by direct measurement of difference of speeds at extremities of given arc on belt.

Workshop Economics. Belting Economics in Workshops (Riemenwirtschaft in Betrieben), F. Rieser. Werkstattstechnik, vol. 20, no. 13, July 1, 1926, pp. 408–414, 10 figs. Making card inventory of belts, giving details of use, location, speed, diameter of pulley, etc.; treatment of orders for belting; upkeep of belting; management of belting for large concerns.

BOILER EXPLOSIONS

Blow-Down Accident. A Boiler Blow-Down Accident. Engineer, vol. 142, no. 3682, Aug. 6, 1926, p. 142, 1 fig. Abstract of report concerning explosion of blow-down tank.

BOILER FEEDWATER

Analysis. Water in Boiler Operation (Das Wasser in der Dampf- und Wärmetechnik), C. Blacher. Feuerungstechnik, vol. 14, nos. 13 and 15, Apr. 1 and May 1, 1926, pp. 153–156 and 178–179, 3 figs. Rapid analysis of water circulating in boiler and control of reliability of results; colloido-chemical theory of suspensions and emulsions, and law of adsorption applied to phenomena observed in steam plants; explanation of local pock-marked corrosion in interior of boiler; role of penetrating air.

Interpretation of Boiler Water Analysis, D. C. Carmichael. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, p. 943. Inasmuch as sodium sulphate makes up large percentage of total solids of most boiler waters, it is reasonable to believe that it is one of the most active causes for priming; therefore, it becomes necessary to remove this salt by blowing down frequently.

Preheating Pump. Preheating Pump (Vorwärmpumpe), E. Josse. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 25, June 19, 1926, pp. 853–854, 3 figs. Pump developed by firm of F. Seiffert & Co., Berlin, in which boiler feedwater is heated by direct contact with bleeder steam within pump.

Regulation. Crawford Ave. Tests Prove the Value of Constant Pressure Differential in Feed-Water Regulation. Power, vol. 64, no. 10, Sept. 7, 1926, pp. 357–358, 1 fig. Series of tests made at Chicago's newest station show advantages of maintaining constant-pressure differential across feedwater regulator, so that having but one variable to contend with, it will more closely maintain feed in accordance with steam demand.

Treatment. Feed Water Treatment and Continuous Sludge Removal. Eng. & Boiler House Rev., vol. 40, no. 2, Aug. 1926, pp. 76–80, 4 figs. Details of continuous sludge and return device.

The Prevention of Boiler Corrosion. Eng. & Boiler House Rev., vol. 40, no. 2, Aug. 1926, pp. 70–75, 3 figs. Considers problems involved in preparing feedwater for boiler after it has been freed from its solid content; experience of G. & J. Weir, who have made special study of this aspect of feedwater problem.

BOILER FIRING

Pulverized-Coal Auxiliary. Auxiliary Firing with Pulverized Lignite (Braunkohlenstaub-Zusatzfeuerungen), L. Finckh. Wärme, vol. 49, no. 22, May 28, 1926, pp. 379–384, 3 figs. Use of auxiliary firing; results of tests to determine efficiency and economy; types of equipment; conclusions.

BOILER FURNACES

Additional Direct Heating Surface. Does Additional Direct Heating Surface Pay? J. G. Coutant. Combustion, vol. 15, no. 2, Aug. 1926, pp. 106–107, 2 figs. Demonstrates economical features of additional direct heating surface.

Traveling-Grate Stokers, for. Furnace Design for Traveling Grate Stokers, H. S. Colby. Power Plant Eng., vol. 30, nos. 5, 6 and 7, Mar. 1, 15 and Apr. 1, 1926, pp. 313–316, 365–366 and 412–415, 9 figs. Present application of arches is due to forced draft, increasing demands for higher ratings and use of special fuel sizes. Points out that when burning fine sizes of anthracite or coke breeze, length and slope of rear arch are of prime importance.

Water-Wall and Well Type. Water Wall and Well Type Furnaces, A. A. Fette. Nat. Engr., vol. 30, no. 8, Aug. 1926, pp. 351–355, 3 figs. Design details, principles of operation and applications of water-wall furnaces; performance records and test results in actual practice; principle of operation of well-type furnaces and performance records in recent installations.

BOILER OPERATION

Meter Control. How the Bailey Meter Control Operates. Power, vol. 64, no. 6, Aug. 10, 1926, pp. 198–202, 7 figs. System utilizes electrical motive power; it is in two distinct parts, one to maintain output, the other efficiency.

BOILER PLANTS

Mines. Recent Boiler-House Construction in Rheinisch Westphalia (Einige neuere Kesselhausbauten im rheinisch-westfälischen Industriegebiet), H. Craemer. Beton u. Eisen, vol. 25, no. 11, June 5, 1926, pp. 189–191, 9 figs. Boiler houses of Fortuna mine near Bergheim and of Bismark mine near Gelsenkirchen, for pulverized-coal firing, constructed by Dyckerhoff A. G. embodying principle that substitution of manual work by machinery not only leads to more exact and reliable working, but is also more economical.

Waste-Coke-Fired. Steam Generation with Waste Coke (Neuerungen in der Dampferzeugung aus Abfallkoks). Gas- u. Wasserfach, vol. 69, no. 20, May 15, 1926, pp. 393–399, 12 figs. Describes new boiler plant of Stuttgart Gas Works using coke of 0 to 7 mm., 7 to 12 mm. and 12 to 18 mm., with forced draft, traveling grate and tar-oil injection, etc., yielding considerable reduction in cost of steam.

BOILER PLATE

Cracks in Seams. Intercrystalline Cracks in Riveted Seams, H. Kriegsheim. Power, vol. 64, no. 7, Aug. 17, 1926, p. 261. Author maintains that intercrystalline cracks in boiler seams are fully explained by action of prolonged high total stresses, and that high internal stress, when present, is due to unsuitable mechanical or thermal treatment of material during manufacture or operation.

BOILERS

Corrosion. The Problem of Steam Boiler Corrosion, F. N. Speller. Am. Water Works Assn.—Jl., vol. 16, no. 1, July 1926, pp. 72–95, 2 figs. Mechanism of corrosion; important factors in boiler corrosion; feedwater in general; dissolved oxygen; carbon dioxide; influence of scale; organic matter; influence of composition of materials of construction; preventive measures.

Electrically Heated. Modern Designs of Electrode Steam Boilers, Zeulmann. Eng. Progress, vol. 7, no. 7, July 1926, pp. 174–176, 9 figs. Principal characteristics of individual types.

French Code. Regulations for Steam Boilers other than Those Used Aboard Ship (Règlement sur les appareils à vapeur autres que ceux placés à bord des bateaux), Monzie. Assns. Françaises de Propriétaires d'Appareils à Vapeur—Bul., no. 24, Apr. 1926, pp. 81–84. Text of new law of April 2, 1926, regulating use, construction and test of steam boilers used on land; also explanatory report to French President.

Heads. Calculation of Dished Boiler Heads (Zur Frage der Berechnung gewölbter Kesselböden), P. Guhlke. Wärme, vol. 49, no. 26, June 25, 1926, pp. 453–454, 1 fig. Godesberger formula for dished boiler heads gives too high pressures for thick walls; therefore a new formula is derived for such heads.

High-Pressure. High Pressure Steam and Central Stations (Hochdruckdampf und Elektrizitätswerke), X. Mayer. Elektrizitätswirtschaft, special no., 1926, pp. 2–19, 25 figs. Discusses introduction of high-pressure steam and extra superheating, and problems connected with their use in central stations; Schmidt, Hanomag, Atmos, and other Boilers.

Scale Prevention. Preventing Hard Scale and Corrosion in Boilers, E. C. Chamberlain. Combustion, vol. 15, no. 2, Aug. 1926, pp. 101–103. Ferro-Chem process, which has been in successful use on small scale for 15 years in California, has been improved and developed and is now applied commercially in boiler room.

Size, Load, and Rating. Size, Load and Rating of Boilers, C. H. Berry. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 314–315. Discusses necessity for distinguishing accurately three basic quantities: (1) size of unit as physical structure, (2) load on unit, and (3) ratio of load to size; size of boiler should be expressed in square feet of heating surface; load in K.B.t.u. per hr., and rating K.B.t.u. per sq. ft. per hr.

BOILERS, WATER-TUBE

High-Pressure. High-Pressure Vertical Boilers (Hochdruck-Steilrohrkesselanlagen), H. F. Lichte. Wärme, vol. 49, nos. 19, 20, 21, 22, 23, 24 and 25, May 7, 14, 21, 28, June 4, 11 and 18, 1926, pp. 325–330, 347–352, 364–367, 401–405, 422–424 and 438–439, 59 figs. Critical description of various types of vertical-tube boilers built by German manufacturers for high pressures, including boilers with stacks of curved tubes, straight tubes, cross drums, longitudinal drums, etc.; construction features of about 32 boilers; test data and operating experience; author claims that boilers of this type are second to none for heating surfaces up to 16,000 sq. ft., and larger boilers up to 27,000 sq. ft. are being developed.

High-Pressure Vertical Water-Tube Boilers (Hochdruck-Steilrohrkessel), Schuller. Hanomag Nachrichten, vol. 13, no. 150–151, Apr.-May 1926, pp. 50–70, 27 figs. Discusses economy attainable by use of high-pressure steam; properties of materials for high-pressure boiler construction; riveted, welded, and pressed or drawn rivetless drums; installations of Hanomag vertical high-pressure boilers, etc.

BOLTS

Heat-Treated. Heat-Treated Bolts, O. D. North. Automobile Engr., vol. 15, no. 217, July 1926, pp. 252–253. Factors influencing application; manufacture; material.

Heat-Treated Bolts, A. C. Burgoine. Automobile Engr., vol. 16, no. 218, Aug. 1926, pp. 299–300. Their use in automobile construction.

Standard. Basis for Determining the Proportions of Standard T-Slots and Bolts, L. D. Burlingame. Mech. Eng., vol. 48, no. 8, Aug. 1926, pp. 838–842, 7 figs. Tests conducted to ascertain comparative strength of bolts and slots in order that proportions submitted might be suited to practical needs.

Stresses. Stresses on Bolts—Nut Dimensions—Wrench Design, G. S. Case. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 919–925, 10 figs. Account of study made to cover data concerning resistance of bolts, nuts, and wrenches to stress that might be of value in their design, selection, and use.

BONUS SYSTEMS

Maintenance Work. Applying a Bonus Plan to Maintenance Work, R. M. Hidey and H. Hylkema. Indus. Engr., vol. 84, no. 8, Aug. 1926, pp. 345–349, 6 figs. System employed by White Motor Co., Cleveland, Ohio.

BORING MACHINES

Screw Cutting. Screwcutting on the Horizontal Boring Machine, H. C. Town. Machy. (Lond.), vol. 28, no. 721, Aug. 5, 1926, pp. 521–522, 5 figs. Describes three screw-cutting attachments.

BRASS FOUNDRIES

Conveyor System. Brass Shop Uses Conveyors, E. C. Barringer. Foundry, vol. 54, no. 13, July 1, 1926, pp. 517–519, 4 figs. Details of conveyor and sand-handling equipment.

Ford Motor Co. The Ford Brass Foundries, R. M. Polhamus. Metal Industry (N. Y.), vol. 24, no. 8, Aug. 1926, p. 321, 2 figs. Methods and equipment of foundries operated by Ford Motor Co. in Highland Park, Mich.

BRONZES

Statuary and Art. Statuary and Art Bronzes. Metal Industry (N. Y.), vol. 24, no. 8, Aug. 1926, pp. 315–317, 9 figs. Describes work of bronze foundries of J. Williams, Inc., New York; main business of company is casting and finishing of bronze statuary, architectural work and tablets; plant includes foundry, molding, melting, pattern, chasing, fitting, finishing, brazing, coloring, and lacquering departments.

C

CARBON MONOXIDE

Combustion of. The Combustion of Carbonic Oxide. Gas World, vol. 85, no. 2188, July 10, 1926, pp. 34–38, 7 figs. Spectrographic investigations; effect of progressive drying; theories proved by experiment; explosion of rigidly dried mixtures of carbon monoxide and oxygen; experiments showing influence of pressure.

CASE-HARDENING

Rotary Carburizing. Rotary Carburizing, S. P. Rockwell. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 12–14. General practice in using rotary machines, including selection of carburizers, loading, timing, sampling, discharging work, and miscellaneous details.

CAST IRON

Carbon in. Determining Carbon in Cast Iron, J. T. MacKenzie. Iron Age, vol. 118, no. 7, Aug. 12, 1926, pp. 415–416, 1 fig. Simplified combustion train found satisfactory for routine analyses in laboratory of large cast-iron pipe foundry.

Chilled. Chilled Cast Iron. Automobile Engr., vol. 16, no. 217, July 1926, p. 265. Metallurgical and practical considerations involved in production of chilled castings.

Grey. Grey Iron Castings for Special Needs, H. J. Young. Mar. Eng. & Motorship Bldr., vol. 49, no. 588, Aug. 1926, pp. 307–311, 9 figs. Particulars of comparative tests carried out by author; importance of low silicon content; utility of serial photographs; impact tests on cast irons. Abstract. Paper read before West of Scotland Iron & Steel Inst.

High-Strength. Production of High-Strength Cast Iron, Gilles. Foundry Trade Jl., vol. 34, no. 518, July 22, 1926, pp. 70–73 and (discussion) 73–75, 1 fig. Melting facilities, electric-furnace iron; pearlitic iron; Emmel's results; Wuest cupola and high tensiles; value of superheating; producing low carbon; treating coke for retarding combustion. Translated from Giesserei-Zeitung.

Pearlitic. Grey Iron Castings for Special Needs, H. J. Young. Foundry Trade Jl., vol. 34, no. 520, Aug. 5, 1926, pp. 117–121, 9 figs. Latest practice in cast iron and summary of present position; it has been demonstrated to satisfaction of author that Perlit procedure is applicable to all classes of foundry practice, and that success depends upon skill of molder and metallurgist in same degree as it attends manufacture of castings of all other alloys and of steel. (Abstract.) Paper presented before West of Scotland Iron & Steel Inst.

Shrinkage. Metal Shrinkage, J. H. List. Foundry Trade Jl., vol. 34, no. 519, July 29, 1926, p. 100, 3 figs. Discusses methods employed to overcome fluid shrinkage, and tests made with object of preventing this shrinkage in large shaft couplings by means of chills and densers; describes one method whereby good castings, despite this shrinkage trouble, can be produced.

Superheated Steam, Effect of. The Behavior of Cast Iron in Superheated Steam (Einige Beobachtungen über das Verhalten von Gusseisen in Heissdampf), E. Piwowarsky. Giesserei, vol. 13, no. 27, July 3, 1926, pp. 481–484, 8 figs. Results of treatment of different varieties of cast iron in steam jet of 300 to 350 and 450 deg. cent. and determination of weight and volumetric increase in relation with oxygen and residue determinations.

Testing. The Mechanical Testing of Cast Iron, H. R. Pitt. Foundry Trade Jl., vol. 34, no. 519, July 29, 1926, pp. 93–97, 4 figs. Principles of testing and special care and precautions necessary in applying accepted methods of testing to cast iron, to co-relate tests and consider their values as applied to material.

The Testing of Cast Iron at the Fourth Foundry Show in Düsseldorf (Die Prüfung des Gusseisens auf der 4. Giessereifachausstellung in Düsseldorf), Rudeloff. Giesserei, vol. 13, no. 30, July 24, 1926, pp. 525–535, 31 figs. Details of testing machines exhibited, investigation of their recording accuracy, and testing workability of iron.

Volume Change at Solidification. Volume Change of Cast Iron at Solidification (Die Volumenänderung von Gusseisen beim Erstarren, etc.), K. Honda and H. Endo. Zeit. für anorganische u. allgemeine Chemie, vol. 154, June 6, 1926, pp. 238–252, 8 figs. Includes critical discussion of double diagram of iron-carbon system; it is shown that graphite present in cast iron is product of decomposition of cementite which separates from charge at high temperature.

CASTINGS

Hydraulic Runners. Canadian Foundry Makes Large Hydraulic Runner. Foundry, vol. 54, no. 15, Aug. 1, 1926, pp. 601 and 610, 3 figs. Methods employed at plant of National Bronze Co., Montreal, in casting hydraulic runner 4 ft. in diameter and 3 ft. high; it has 19 blades and weighs 4500 lb.; casting is made of special maganese bronze.

Testing. The Testing of Castings. Metallurgist (Supp. to Engineer, vol. 142, no. 3681), July 30, 1926, pp. 98–99. Discusses difficulties which surround satisfactory testing, and therefore drafting of sound specifications; production and use of test bars; if test bar is cooled at rate that differs widely from that occurring in casting itself, then sound test bar affords no guarantee of an equally sound casting.

CENTRAL STATIONS

Cleveland, Ohio. Features of Avon Station. Elec. World, vol. 88, no. 6, Aug. 7, 1926, pp. 260–272, 20 figs. New plant of Cleveland Elec. Illuminating Co. operates on regenerative cycle, using pulverized fuel exclusively; reliability, simplicity, and safety predominate in electrical and mechanical design.

Diesel-Engined. Diesel Makes Ideal Steam Plant Standby, C. C. Hermann. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, p. 900, 1 fig. Even with heating load thermal efficiency will often outweigh other disadvantages; details of 750-hp. McIntosh & Seymour Diesel in municipal plant of Cedar Falls, Iowa.

Diesel Savings Finance City Improvements. Oil Engine Power, vol. 5, no. 8, Aug. 1926, pp. 478–479, 3 figs. Description of plant and data on operating expense, New Iberia, La.

Load Conditions of German Central Stations and Their Improvement by Using Diesel Engines for Peak Loads (Die Belastungsverhältnisse der deutschen Grosskraftwerke und die Verbesserung ihrer wirtschaftlichen Folgen durch Spitzen-Grossdieselmotoren), M. Gercke. Elektrizitätswirtschaft, vol. 25, nos. 407 and 408, Apr. 2 and May 1, 1926, pp. 169–176 and 201–207, 22 figs. Gives winter and summer load curves for number of German average central stations; discusses effect of peak loads on heat economy, and how Diesel engines may best be used for peak loads; prices of solid and liquid fuel and their effect.

Fuel-Burning Equipment. The Selection of Fuel-Burning Equipment for Generating Stations, G. W. Keen. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 947–948. Discusses advantages and disadvantages of stokers and pulverized-fuel-burning equipment; factors to be considered are cost of installation and operation; reliability, etc.

Germany. Recent Additions to the Charlottenburg Central Station (Neuzeitlicher Umbau des Kraftwerkes Charlottenburg), F. Ohlmüller. Elektrotechnische Zeit., vol. 47, no. 17, Apr. 29, 1926, pp. 494–500, 13 figs. Older machine, installed in 1925, is 16,000 kw. and operates with steam pressure of 180 lb. per sq. in.; to this has been added a 700-kw. high-pressure set at 500 lb. per sq. in. exhausting at 180 lb. per sq. in. into older set, bringing total output of combined unit up to 23,000 kw.; two more similar combined units are being added, bringing total station output up to 70,000 kw.; boiler plant consists of 12 Babcock-type water-tube boilers; coal is mechanically handled throughout by conveyors capable of dealing with 66 tons per hr., and deposited in 1700-ton hoppers above boiler house, from which it feeds directly to boilers. See brief translated abstract in Sci. Abstracts (Section B), vol. 29, no. 343, July 25, 1926, p. 32.

Interconnection. Economies of System Interconnection, H. V. Bozell. Elec. World, vol. 88, no. 6, Aug. 7, 1926, pp. 273–275. A few examples of interconnection in electric light and power industry reduced to dollars-and-cents results.

Kearny, New Jersey. The Kearny Station of the Public Service Electric Power Company, R. J. S. Pigott. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 306–312, 8 figs. Present installation of 185,000 kw. is half of ultimate plant; operating on regenerative cycle, plant relies for efficiency on superior operation of simple equipment rather than on addition of special heat-recovery devices.

Liverpool. Electricity Supply at Liverpool. Elec. Rev., vol. 99, no. 2541, Aug. 6, 1926, pp. 211–214, 10 figs. Details of recent extensions of City Corporation's undertaking; new Lister Drive No. 3 station, when completed, will be capable of housing 5 sets of 25,000 kw. each; boiler house contains 4 Babcock and Wilcox and 2 Yarrow units, each capable of evaporating 60,000 lb. of steam per hour.

New York Edison Co. New York Will Soon Have Thirty Million New Electric Slaves, E. E. Free. Edison Monthly, July 1926, pp. 3–13, 4 figs. Description in popular style of new East River Station of New York Edison Co.

Pulverized-Coal-Burning. Experiences at Cahokia, E. L. Clifford and E. H. Tenney. Power, vol. 64, no. 8, Aug. 24, 1926, pp. 268–274, 5 figs. Engineering development and operating experience after more than two years' operation; slag and smoke present problems; air preheaters installed; boiler and furnace appurtenances; steam utilization.

Virginian Railway Adopts Pulverized Coal for Widely Fluctuating Load. Power, vol. 64, no. 10, Sept. 7, 1926, pp. 359–362, 5 figs. In new station located at Narrows, Va., initial installation includes five 15,210-sq. ft. cross-drum boilers and four 10,000-kw. generating units; preparation equipment is located beside boiler; plant supplies power for haulage of coal trains over Allegheny Mts.

CHAIN DRIVE

Sprockets. The Manufacture of Sprockets for Chains (La fabrication des pignons pour chaînes). Pratique des Industries Mécaniques, vol. 9, no. 4, July 1926, pp. 140–144, 14 figs. Methods of designing sprockets for use with roller and silent chain, and of cutting teeth on same.

CHIMNEYS

Calculation. Foundations and Pressures in Freely Supported Circular Stacks (Ankerzüge und Mauerpressungen für freistehende, nicht abgespannte, Runde Trommeln), M. Zebe. Bauingenieur, vol. 7, no. 25, June 18, 1926, pp. 493–498, 7 figs. Develops formulas for rapid approximate calculations applying to steel stacks, coolers, reinforced-concrete stacks and pipe.

Draft. Means of Increasing Draft of Chimneys (Mittel zur Erhöhung der Zugkraft von Schornsteinen), A. Burghardt. Feuerungstechnik, vol. 14, no. 16, May 15, 1926, pp. 191–192. Draft resistances; movement of gases; decrease of draft and means of increasing it; artificial draft; application of inside lining.

COAL

Carbonization. The Carbonisation of Coal, J. Roberts. Combustion, vol. 15, no. 2, Aug. 1926, pp. 98–100. Combustion of anthracite and of coke; coal by-products; waste of volatile products; natural fuels.

Carbonisation of Coal in Continuous Vertical Retorts. Colliery Guardian, vol. 132, no. 3420, July 16, 1926, pp. 131–132. Report of Fuel Research Board.

The Low-Temperature Carbonisation of Coal, A. C. Fieldner. Fuel, vol. 5, no. 6, June 1926, pp. 265–271, 10 figs. Internally heated retorts; coal in direct contact with gases or liquids; coal in screened lumps or briquettes; directly heated by hot gases generated by air blown into retort; Hood-Odell lignite carbonizing process; McEwen-Runge process of carbonizing powdered coal by hot gases; Seidenschnur-Pape process of heating coal by hot products of combustion generated outside retort proper; Lurgi process.

Some Problems in the Carbonisation Industries, H. M. Spiers and T. C. Finlayson. Indus. Chemist, vol. 2, no. 18, July 1926, pp. 315–318, 2 figs. Coal washing and drying; choice of carbonizing plant; refractories, waste heat, gas condensation, benzol recovery, gas purification, tar and coke quenching; low-temperature carbonization.

Vertical Retort for Low Temperature Carbonization. Fuels & Furnaces, vol. 4, no. 8, Aug. 1926, pp. 915–916, 3 figs. Experimental plant for low-temperature carbonization of lignite developed by Coal Improvement Co., Germany; new carbonizing furnace is rotating vertical retort.

Coking. The Coking Constituents of Mesa Verda and Pittsburgh Coals, J. D. Davis and D. A. Reynolds. Indus. & Eng. Chem., vol. 18, no. 8, Aug. 1926, pp. 838–841, 3 figs. Coking constituents of Mesa Verda and Pittsburgh coals were investigated by method of Fischer, which consists in extraction of coal bitumens by benzene under pressure, separation into solid and oily bitumens by petroleum ether, and testing them separately by volatile-matter coking test.

Constitution. The Constitution of Coal, S. W. Parr. Indus. & Eng. Chem., vol. 18, no. 6, June 1926, pp. 640–648, 23 figs. With special reference to problems of carbonization.

Fusion. The Transient Fusion of Coal, E. Audibert. Fuel, vol. 5, no. 6, June 1926, pp. 229–244, 18 figs. To be suitable for use in blast furnace, coke must possess mechanical strength, which necessitates: (1) that all its component parts are sufficiently strong, (2) that structure is compact and not too spongy, (3) that mass does not have too many fissures; researches show nature and mode of action of factors determining inherent strength of coke. Translated from Revue de l'Industrie Minérale.

COAL GAS

Calorific Value. Measuring the Calorific Value of Illuminating Gas (Mesure du pouvoir calorifique du Gaz d'Eclairage), M. Bousquet. Vie Technique & Industrielle, vol. 8, no. 80, May 1926, pp. 61–69, 11 figs. Design and accuracy of ordinary and recording calorimeters by Junkers used by Paris Gas Works; Lemoult, Simmance-Abady, and Sarco.

COAL HANDLING

Equipment. Economic Fuel Handling and Storage, W. T. Conlon. Mfg. Industries, vol. 12, no. 2, Aug. 1926, pp. 97–100, 5 figs. Equipment and methods that have saved money and prevented low grading and fires.

Plants. New Coal Handling Plant at Beckton. Engineer, vol. 142, no. 3679, July 16, 1926, pp. 69–71, 4 figs. Combined equipment of cranes and conveyors, which will be capable of dealing with 2000 tons of coal per hour, is claimed to be largest installation of its kind in Europe. See also Engineering, vol. 122, no. 3158, July 23, 1926, pp. 103–105, 4 figs.

COAL STORAGE

Bituminous Coal. The Why, When and How of Storing Bituminous Coal, W. T. Conlon. Power, vol. 64, no. 10, Sept. 7, 1926, pp. 354–356, 5 figs. By placing coal so as to prevent air circulation through it, a pile 20 ft. high showed no indications of fires after 26 months' storage.

Spontaneous Combustion. Does Carbon Dioxide Set Fire to Coal Storage Piles? H. G. Turner and E. Sinkinson. Coal Age, vol. 30, no. 5, July 29, 1926, pp. 139–140, 3 figs.

COKE

Dry Cooling. The Sulzer System of Dry Coke Cooling, E. Blau. Gas Age-Rec., vol. 58, no. 5, July 31, 1926, pp. 135–136 and 145, 2 figs. Process of Sulzer Bros. of Winterthur, Switzerland, in which sensible heat obtained from cooling of hot coke is used to produce high-pressure steam; sensible heat of coke is utilized by charging incandescent coke into closed tanks which are not only equipped with necessary loading, discharging and safety devices but also connected up with boiler in such manner that whole forms single closed unit.

Lignite. Coking Experiments with Lignite (Verkokungsversuche mit Lignit), H. Romberg. Braunkohle, vol. 25, no. 16, July 17, 1926, pp. 329–335. Discusses experiments to produce metallurgical coke from Styrian lignites to replace charcoal; concludes that if by-products of distillation can be used to advantage, lignite coke is feasible.

Powdered Semi-Coke. Some Tests on Powdered Semi-Coke for Boiler Firing. Eng. & Boiler House Rev., vol. 40, no. 2, Aug. 1926, pp. 65–66, 2 figs. Results of tests carried out on water-tube boiler fired with semi-coke in powdered form.

Quenching. "Heller-Bamag" Coke Quenching System. Gas Jl., vol. 175, no. 3295, July 14, 1926, pp. 86, 1 fig. Description of Heller-Bamag system in which coke is quenched in steam-tight chamber by spray of highly superheated water.

Coke Quenching and Handling, C. F. Ellwood. Iron & Coal Trades Rev., vol. 113, no. 3044, July 2, 1926, pp. 14–15, 7 figs. Methods of quenching; inclined bench; inclined bench and conveyor.

Goodall Coke-Quenching and Loading Machine. Iron & Coal Trades Rev., vol. 113, no. 3046, July 16, 1926, pp. 83–84, 5 figs. Details of its construction and operation.

COKE OVENS

Gas Regulation. Gas is Regulated Automatically, E. X. Schmidt. Iron Trade Rev., vol. 79, no. 8, Aug. 19, 1926, pp. 441–444, 4 figs. Calorimeter of recent design affords continuous record of heating value and reduces labor of maintaining desirable flow of potential heat in by-product oven practice; manipulation is described.

Heating. Modern Systems of Coke-Oven Heating (Zur Frage der modernen Koksofen-Beheizung), H. Kuhn. Feuerungstechnik, vol. 14, nos. 12, 13 and 14, Mar. 15, Apr. 1 and 15, 1926, pp. 142–145, 156–158 and 169–171, 12 figs. Single-stage coke-oven heating; multiple-stage heating according to Still system; maximum temperatures and heat consumption of single- and multiple-stage systems.

Multi-Flame. The "Still" Multi-Flame Coke Oven, H. Kuhn. Iron & Coal Trades Rev., vol. 113, no. 3045, July 9, 1926, pp. 50–53, 7 figs. Examination, on basis of actual measurements of temperature of progress from single-flame to multi-flame combustion system is indicated by two important achievements, namely, the uniformity of vertical temperatures and material reduction in heat requirements for under firing.

COLD STORAGE

European Plants. European Cold Stores at North Sea Ports. Cold Storage, vol. 29, no. 340, July 15, 1926, pp. 298–300, 5 figs. Plants at Hook of Holland, and at Bremerhaven.

COMPRESSED AIR

Shipyards. Shipyard Pneumatic Plant, J. A. Cromar. Shipbldg. & Shipg. Rec., vol. 28, no. 3, July 15, 1926, p. 67, 1 fig. Suggested method of control to minimize waste of air.

CONDENSERS, STEAM

Jet. Increasing the Capacity of Jet Condenser, J. Harvey. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 319–322, 6 figs. History of changes made in jet condenser whereby its steam-condensing capacity has been doubled; influence of structure on operating characteristics.

Tube Dezincification. Condenser-Tube Dezincification, C. E. Colborn. Power, vol. 64, no. 10, Sept. 7, 1926, p. 374. Observations of numerous condensers after various lengths of service led the writer to believe that dezincification might be greatly retarded or perhaps prevented by the proper cleaning of tubes.

CORES

Drying. A New Type of Drying Plant for Foundry Cores (Ein neuartige Trocknungsanlage für Giessereikerne), L. Schmid. Giesserei-Zeitung, vol. 23, no. 14, July 15, 1926, pp. 386–388, 2 figs. Defects and disadvantages of usual core-drying compartments; describes new drying equipment developed along entirely different lines, consisting of three drying pits and three conveyor baskets capable of being lowered, and of an entirely separate hot-air generator.

Making. Produce Cores by Thousands with Watchmaking Accuracy, P. Dwyer. Foundry, vol. 54, no. 16, Aug. 15, 1926, pp. 638–642, 7 figs. Coremaking facilities and equipment which have been installed in the Central Foundry of Saginaw Products Co., Saginaw, Mich.

COST ACCOUNTING

Forge Shop. Forge Shop Production; Cost Accounting, F. S. Hatch. Forging—Stamping—Heat Treating, vol. 12, no. 7, July 1926, pp. 235–238. Enthusiastic organization with confidence in management is essential to high production; carefully planned cost system is invaluable.

CRANKSHAFT

Forging. Mechanical Forging of Crankshafts (Maschinelles Schmieden gekröpfter Wellen), M. v. Beauvais. Praktischer Maschinen-Konstrukteur, vol. 59, no. 19–20, May 15, 1926, pp. 196–197, 8 figs. Method based on principle of feeding metal to all points where reduction of cross-sectional area may occur during bending in order to avoid reduction of area.

CUPOLAS

Coke. Cupola Coke (Ueber Kupolofenkoks). Brennstoff- u. Wärmewirtschaft, vol. 8, no. 9, 1st May no., 1926, pp. 146–148. Points out that mechanical and chemical properties of coke, its hardness and strength, porosity and calorific value, are main factors in cupola melting.

Design. Cupola Installations in Foundries (Ofenanlagen in der Giesserei), W. Hollinderbäumer. Giesserei, vol. 13, nos. 28 and 29, July 10 and 17, 1926, pp. 493–500 and 513–517, 13 figs. Present status of cupola design; drying of forms with different drying-furnace installations.

Operation. Operating the Cupola Efficiently, R. Micks. Can. Foundryman, vol. 17, no. 7, July 1926, pp. 7–9. Lining cupola; charging; location of slag hole; melting losses of metal; mixing of iron a factor in production.

Shaking Hearth. Jigger Hearth for Cast Iron, C. Irresberger. Foundry Trade Jl., vol. 34, no. 518, July 22, 1926, pp. 64–65, 1 fig. Describes hearth developed by J. Dechesne; efforts to desulphurize cast iron suggested idea of trying to effect this by jigging and shaking freshly tapped metal; characteristic of effects of jigging is possibility of very liberal steel additions without endangering casting capabilities owing to viscousness, without risk of piping and without tendency to white solidification. Translated from Stahl u. Eisen, June 30, 1926. See also Iron Age, vol. 118, no. 7, Aug. 12, 1926, pp. 413–414, 2 figs.

Shaking Hearth for Refining of Molten Cast Iron and Steel (Rüttelherd zur Vergütung von flüssigem Gusseisen und Stahl), C. Irresberger. Stahl u. Eisen, vol. 46, no. 26, June 30, 1926, pp. 869–872, 3 figs. Example of shaking hearth, developed by J. Dechesne, for purpose of desulphurizing cast iron; results and advantages, especially for gray-iron, malleable and steel foundries. See also Giesserei-Zeitung, vol. 23, no. 13, July 1, 1926, pp. 355–357 and (discussion), 357–358, 10 figs.

CUTTING METALS

Art of. Advantages of Improving the Metal and Shape of Cutting Edge of Tools (Die Vorteile der Verbesserung des Stoffes und der Scheidenform beim Werkzeug), W. Hippler. Maschinenbau, special no., 1926, pp. 7–12, 11 figs. Examines question as to whether it is more advantageous to improve quality of metal of tool or shape of cutting edge and concludes that in neither direction is there much room for improvement.

Effect of Shape of Chip-Profile on Generation of Heat and Wear of Cutting Edge (Einfluss der Gestalt des Spanquerschnittes auf die Wärmeentwicklung und die Schneidhaltigkeit), G. Engel. Maschinenbau, special no., 1926, pp. 32–42, 27 figs. Discusses Friedrich equation and its deviation for practical cutting speeds; formulates heat generated, etc., shape of chip and heat generation, effect of size of chip profile on wear of cutting edge, determination of economic cutting speeds.

Turning. Maximum Efficiency in Lathe Work (Höchstleistung beim Drehen), E. Baltz. Maschinenbau, special no., 1926, pp. 12–20, 12 figs. Shows that by cooling tool greater efficiency and cutting speed result compared with dry cutting; use of lathes with gear cases and normal feeds and special drive with motor regulatable in ratio of 1:25.

Research and Practice with Cutting Tools (Forschung und Praxis in der Zerspanung), K. Hegner. Maschinenbau, special no., 1926, pp. 1–3, 1 fig. Discusses formulation of fundamental laws and their application in practice; gives AWF table enabling calculation of load for tool steel of given quality, hardness and shape, and details of lathe.

CYLINDERS

Liners. Cylinder Liners. Automobile Engr., vol. 16, no. 218, Aug. 1926, p. 298, 2 figs. Notes on liners produced by centrifugal casting process.

D

DIES

Expanding. Dies for Expanding Pressed Shapes, E. Heller. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 9–11, 3 figs. Construction of expanding dies; operation of die; angle of expanding cone; constructing expanding die.

DIESEL ENGINES

Airless-Injection. New Airless-Injection Diesel with Displacer Piston. Oil Engine Power, vol. 5, no. 8, Aug. 1926, pp. 486–487, 3 figs. 4-cycle machine of small bore and high speed.

De La Vergne. An Interesting Diesel Installation. Mar. Eng. & Shipg. Age, vol. 31, no. 8, Aug. 1926, pp. 482–485, 5 figs. Pilot boat Carmina to be fitted with De La Vergne engine and mechanical reversing and reduction gear; engine is 6-cylinder, 4-cycle single-acting Diesel of non-reversing type and arranged for solid fuel injection.

Deutz. Investigations of the New Deutz Marine Diesel Engine (Untersuchung des neuen Duetzer umsteuerbaren Schiffsdieselmotors), H. Baer. Schiffbau, vol. 27, no. 10, May 19, 1926, pp. 285–288, 4 figs. Engine is of 6-cylinder type and develops 300 b. hp. at 280 r.p.m., starting and reversal being accomplished by compressed air; results of starting and manœuvering tests, fuel and power tests, and overload tests; mechanical efficiency at full load amounted to 83.2 per cent. See also description, by H. L. Meurer, in Werft-Reederei-Hafen, vol. 7, no. 4, Feb. 22, 1926, pp. 110–114, 8 figs.; and brief translated abstract in Mar. Engr. & Motorship Bldr., vol. 49, no. 587, July 1926, p. 275.

Exhaust Gases. Diesel Exhaust Gives Valuable Information. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, p. 901, 2 figs. Conclusions regarding influence of load, speed, fuel, cooling-water temperature and irregularities in engine operation upon temperature and CO_2 content of exhaust, based on tests of horizontal, two-cylinder, four-cycle, belt-drive, Koerting solid-injection engine. Translated from Wärmewirtschaft, Mar. 1926.

15,000-Hp. The World's largest Diesel. Power, vol. 64, no. 8, Aug. 24, 1926, pp. 287–288, 2 figs. Engine of 15,000 hp., installed in electrical works of Hamburg, Germany, having 9 double-acting cylinders; will be used for stand-by service.

Foos. Higher Speed Range for New Engine Model. Oil Engine Power, vol. 5, no. 8, Aug. 1926, pp. 472–476, 5 figs. Engine develops 50 hp. per cylinder and runs up to 900 r.p.m.; complete enclosure without exterior moving parts.

Heavy-Oil-Burning. Burning Heavy Fuel Oil in Diesel Engines, R. Hilderbrand. South. Power Jl., vol. 44, no. 7, July, 1926, pp. 55–56, 3 figs. Showing how heating system assisted in solving problem when used in connection with small engine.

High-Speed. High-Speed Diesel Engines for Motive Power (Schnellaufende Dieselmotoren für Kraftfahrzeuge), Hausfelder. Zeit. für angewandte Chemie, vol. 39, no. 16, Apr. 22, 1926, pp. 518–519. Considers factors to be taken into consideration in designing high-speed engines and reviews recent work of German investigators in this field; in order to increase speed of Diesel engine, two requirements must be satisfied, namely, rapid ignition and rapid combustion; recent experimental work appears to show that shape of combustion chamber has considerable effect on rapidity of combustion. See also brief translated abstract in Fuel, vol. 5, no. 6, June 1926, pp. 272–273.

Lubrication. Some Notes on Marine Lubrication, R. S. Robinson. Mar. Engr. & Motorship Bldr., vol. 49, no. 588, Aug. 1926, pp. 285–286, 1 fig. With particular reference to Diesel-engine lubricants and their purification.

Two-Cycle vs. Four-Cycle. Two- and Four-Cycle Engines Compared. Motorship, vol. 11, no. 8, Aug. 1926, pp. 592–593. Comparison of year's operation of Japanese Transpacific motorships Atago Maru and Asuka Maru.

Winton. Winton Model 114 Diesel Engine. Mar. Eng. & Shipg. Age, vol. 31, no. 8, Aug. 1926, pp. 460–463, 10 figs. Type of engine to be installed in Coast Guard patrol boats; engine is of 6-cylinder, 4-cycle, single-acting type arranged for air injection of fuel.

DRAWINGS

Blueprints. Blue-Prints and Van-Dyke Prints at Minimum Cost, A. A. McCormack. Mfg. Industries, vol. 12, no. 2, Aug. 1926, pp. 133–134. Economy of modern equipment and methods.

DRILLING MACHINES

Hoefer. Repetition Drilling of Pistons. Automobile Engr., vol. 16, no. 217, July 1926, pp. 258–259, 3 figs. Description of three drilling machines made by Hoefer Mfg. Co., Freeport, Ill.

Inverted-Spindle. Inverted Spindle Drilling Machine. Machy. (Lond.), vol. 28, no. 720, July 29, 1926, pp. 490–491, 3 figs. Five-spindle machine developed by Selson Eng. Co., Coventry, for work requiring drilling of blind holes such as float-chamber aperture in carburetor bodies.

Multi-Spindle. Multi-Spindle Drilling. Brit. Machine Tool Eng., vol. 4, no. 40, July-Aug. 1926, pp 453–458, 8 figs. Reviews contemporary practice in various machining operations, giving representative examples of drilling machines and attachments that have effected economies in production.

Radial. All-Geared Radial Drilling Machine. Engineer, vol. 142, no. 3681, July 30, 1926, pp. 122–123, 4 figs. Machine made by Midgley & Sutcliffe, Bradford, Eng.; features of particular interest are pillar about which radial arm rotates, eight-speed gear box and enclosed spindle head.

New 7 Ft. Universal Portable Radial Drilling and Tapping Machine. Brit. Machine Tool Eng., vol. 4, no. 40, July-Aug. 1926, pp. 444–447, 4 figs. Large electrically driven machine developed by Wm. Asquith, Ltd.

Types. Drilling and Honing Machines. West. Machy. World, vol. 17, no. 7, July 1926, pp. 305–308, 11 figs. Descriptions of various types.

Vertical-Gang. The Archdale Heavy Duty Manufacturing Vertical Gang Drilling Machine. Brit. Machine Tool Eng., vol. 4, no. 40, July-Aug. 1926, pp 441–443, 2 figs. So designed that it may be supplied either as single-head machine or with heads mounted in gang form upon common base, in which case each head may be supplied with individual table or long table common to all heads.

DRILLS

Twist. Making Milled Twist Drills, A. E. Granville. Can. Machy., vol. 36, no. 6, Aug. 5, 1926, pp. 19–21, 9 figs. Describes how either tool-steel or high-speed drills are made from round bar stock when flues are milled.

E

EDUCATION, ENGINEERING

Aid to Industry. Can the University Aid Industry? B. F. Bailey. Am Inst. of Elec. Engrs.—Jl., vol. 45, no. 8, Aug. 1926, pp. 742–745. Author believes there is growing spirit of coöperation between industry and university, and it is believed that this tendency to coöperate will continue and will be of great advantage to both parties.

Continuation Courses. Continuation Courses for Engineers (Fortbildungskurse für Ingenieure), Heidebroek. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 29, July 17, 1926, pp. 965–967. Main groups of institutions for continuation courses are: Outside institutes of technical high schools; continuation courses of special organizations, and technical-scientific associations; aim and activities of future post-graduate training of engineers; aspects of organization with regard to place, time and costs.

Europe. The Engineering Scene, W. E. Wickenden. Mech. Eng., vol. 48, no. 8, Aug. 1926, pp. 794–796. Critical glance at technical education in Europe and how America may profit by it.

ELEVATORS

Safety Devices. Safety Devices of Elevators and Lifts (Dispositifs de sécurité dans les ascenseurs et monte-charges), G. Baignères. Société des Ingénieurs Civils de France Mémoires et Compte Rendu des Travaux, vol. 79, no. 3–4, 1926, pp. 71–110, 37 figs. Hydraulic elevators, elevators with suspended cages, grips or safety gear of various types; automatic control of elevator doors, etc., of modern elevators, showing that modern practice affords adequate security; text of Paris police regulations.

EMPLOYEES

Stock Ownership. Discussion on Employe Stock Ownership Presented Before the Industrial Relations Section, American Institute of Mining and Metallurgical Engineers, Am. Inst. Min. & Met. Engrs.—Trans., no. 1584-K, Aug. 1926, 22 pp. Discussion of following papers: Organization of Industry, G. E. Roberts; Employee Ownership in Industry, J. M. Shaw; Bethlehem Steel Corporation's Employees Saving and Stock Ownership Plan, J. M. Larkin.

F

FIREBRICK

Spalling. The Mechanism of Spalling, F. H. Norton. Am. Ceramic Soc.—Jl., vol. 9, no. 7, July 1926, pp. 446–461, 20 figs. Study of stresses and fractures developed in solid when rapidly heated or cooled.

FLOW OF AIR

Discharge Formula. The Discharge Formula of Saint-Venant and Wantzel (Die Ausflussformel von de Saint-Venant und Wantzel), F. Kretzschmer. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 29, July 17, 1926, pp. 980–984, 2 figs. Points out that formulas of Saint-Venant and Wantzel in general use for evaluation of compressed-air and steam measurements disregard preliminary velocity and therefore hold true only for discharge from very large containers; exact formulas for flow through pipes.

Turbulence. Divergent and Convergent Turbulent Flow at a Small Angle (Divergente und konvergente turbulente Strömungen mit kleinen Oeffnungswinkeln), F. Dönch. Forschungsarbeiten auf dem Gebiete des Ingenieurwesent, no. 282, 1926, pp. 1–58, 28 figs. Experiments carried out in slightly expanding and constricting rectangular channels (produced by adjustable sides) at Göttingen University with air at velocities of 30 m. per sec. or under.

FLOW OF GASES

Poppet Valves. A Study of the Potential Flow of Gas Through the Poppet Valves, K. Tanaka. Soc. of Mech. Engrs. (Japan)—Jl., vol. 29, no. 3, July 1926, pp. 397–408, 8 figs. Seeks to solve case of tulip-type valve with conical seat in its increased lift, and compares results with those derived by Eck, in other words, with those of plane seated and ordinary conica seated valve. (In English.)

FLOW OF WATER

Pipes. Theoretical Energy Losses in Intersecting Pipes, J. C. Stevens. Eng. News-Rec., vol. 97, no. 4, July 22, 1926, pp. 140–141, 2 figs. Confined to impact and eddies; general formula deduced, with application to number of particular cases.

Turbulence. Investigation of Distribution of Velocity in Turbulent Flow (Untersuchung über die Geschwindigkeitsverteilung in turbulenten Strömungen), J. Nikuradse. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 281, 1926, pp. 1–44, 51 figs. Experiments carried out at Göttingen University to determine distribution of velocity in turbulent flow in pipes with triangular, rectangular, and circular profiles; on the surface of open rectangular channels, and in their cross-section.

FLYING BOATS

Duralumin Hulls, Repairing. Repairing Duralumin Hulls and Pontoons. Aviation, vol. 21, no. 6, Aug. 9, 1926, pp. 242–243, 5 figs. Fractures and punctures in duralumin may be repaired effectively and with great facility.

French. Development of French Flying Boats (L'evolution de l'hydraviation française et les grands raids étrangers), P. Boutiron. Bul. Technique du Bureau Veritas, vol. 8, no. 4, Apr. 1926, pp. 63–67, 6 figs. Reviews recent progress in flying boats abroad; development of French types; air and sea qualities of flying boats; data of C.A.M.S. 37, Schreck, and Météore flying boats, recent flights.

FOREMEN

Patternshops. Patternshop Foremen and Charge Hands, J. Edgar. Foundry Trade Jl., vol. 34, no. 519, July 29, 1926, pp. 101–102. Defects in charge-hand system and alternative systems; staffing patternshops; apprenticeship training.

Selecting. Engaging a New Foreman, F. V. Faulhaber. Brass World, vol. 22, no. 7, July 1926, pp. 225–226. Troubles of factory manager in picking right man for finishing room; promoting insider vs. engaging successful outsider.

Small Shops. Giving Foreman in the Small Shop an Important Role, F. Waldo. Am. Mach., vol. 65, no. 7, Aug. 12, 1926, pp. 285–286, 2 figs. Outline of simple coöperative system that gives foreman incentive to create labor-saving ideas, rewarding him by giving him share of profits.

Training. Developing the Armco Foremen, A. J. Beatty. Am. Mach., vol. 65, no. 8, Aug. 19, 1926, pp. 313–316, 3 figs. Foreman training or development, has been in successful operation for several years at Am. Rolling Mill Co.; fundamentals of course and how they are developed.

Training for Foremanship, F. Cushman. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 906–908. Various plans for providing necessary degree of supervision of men in industrial employment; cycles through which industrial organizations pass as regards functional activities; foreman an indispensable factor in any industrial organization; conference as educational procedure.

FORGE SHOPS

Economies in Heating Practice. Savings in Forge Shops through the Use of Recuperative Furnaces (Ersparnisse in der Schmiede durch Rekuperativöfen), W. Ruppmann. Maschinenbau, vol. 5, no. 13, July 1, 1926, pp. 607–609. Notes on savings possible through employment of suitable reverberatory furnaces; comparison of economies of modern forge shop reverberatory furnace and direct-fired furnace not utilizing waste heat; calculates fuel consumption of both furnaces.

FORGING

Superheater Parts. Forged Return Bends for Superheater Units. Machy. (Lond.), vol. 28, no. 718, July 15, 1926, pp. 423–424, 2 figs. Operation in forging superheater return bends on upsetting type of forging machine.

FORGINGS

Defects in. Defects in Carbon-Vanadium Forgings, O. B. Schultz. Forging—Stamping—Heat Treating, vol. 12, no. 7, July, 1926, pp. 230–234, 9 figs. Defects which have been found in large carbon-vanadium locomotive forgings, and means for their prevention.

Pickling. The Elements of Good Pickling Practice, R. L. Rolf. Forging—Stamping—Heat Treating, vol. 12, no. 7, July 1926, pp. 248–249 and 254. Various factors which enter into practice of pickling are briefly discussed; pickling of forgings; unlike tumbling or sand blasting, reveals defects.

FOUNDRIES

Fuel Economy. Fuel Economy in the Foundry, A. Campion. Metal Industry (Lond.), vol. 29, no. 3, July 16, 1926, pp. 63–65. Fuel consumption in foundry practice; heat generation; temperature of gaseous current; heating in reverberatory furnaces; annealing operations; drying of molds.

Gray-Iron. The Gray Iron Foundry, H. M. Boylston. Fuels & Furnaces, vol. 4, no. 8, Aug. 1926, pp. 905–910, 2 figs. Discussion on pattern design, molding, molding sands and facings, chilled molds, cores; construction and operation of melting furnaces. Abstract of study for treatise on "Iron and Steel."

Jobbing. Erects Modern Casting Plant in Texas, E. H. Trick. Foundry, vol. 54, no. 16, Aug. 15, 1926, pp. 622–626, 10 figs. Methods and equipment of jobbing foundry placed in operation by Alamo Iron Works, San Antonio, for manufacture of gray-iron and brass castings; cupola is 42 in. in diam. with 60-in. shell; total height is 57 ft.

Plate. Plate Foundry at Thorncliffe Ironworks

Iron & Coal Trades Rev., vol. 113, no. 3045, July 9, 1926, p. 49, 2 figs. Methods and equipment of cast-iron plate foundry of Newton Chambers & Co.

Safety in. Safety in Foundries, Nat. Safety News, vol. 14, nos. 1 and 2, July and Aug. 1926, pp. 43–53 and 42–54, 54 figs. No. 73 of series of safe-practices pamphlets. July: Training new man; handling raw material; sand mills, cutters, and sifters; molding and core making; flasks; ovens; foundry floor; cupolas and furnaces; crucible furnaces. Aug.: Open-hearth furnaces, ladles; handling molten metal; shaking out castings; cranes, hoists and accessories; wheelbarrows and trucks; sand buckets; protective clothing; ventilation; heating and lighting.

Statistical Data, United States. Consumated Deflation Shown in Foundry Count. Foundry, vol. 54, no. 16, Aug. 15, 1926, pp. 627–632, 8 figs., 6 tables. Compilation of statistics shows increase in all classes of castings plants except those specializing in gray iron.

Toy Castings. Toys Are Made in Jobbing Shop, F. G. Steinebach. Foundry, vol. 54, no. 13, July 1, 1926, pp. 501–505, 5 figs. Methods and equipment at foundry of A. C. Williams Co., for production of cast-iron toys; much of work is done on molding machines; work is handled on machines of jolt, squeeze type and of jolt-rollover, squeeze, pattern-draw type.

FOUNDRY EQUIPMENT

Heat-Treating. Heat Treatment and Foundry Plant. Machy. (Lond.), vol. 28, no. 719, July 22, 1926, pp. 459–460, 4 figs. Details of coke-fired muffle furnace, No. 2 Simpson intensive sand mixer, and core stove, constructed by August's Muffle Furnaces, Halifax.

Magnetic-Separator Pulleys. Magnetic Separator Pulleys in Foundries, C. H. S. Tupholme. Foundry Trade Jl., vol. 34, no. 518, July 22, 1926, pp. 76–77, 3 figs. Principles and characteristics.

Parting Materials. Composition of Foundry Parting Material. Foundry, vol. 54, no. 13, July 1, 1926, p. 509. Although composition of powder designed to serve as parting medium, placed on market by manufacturers of foundry supplies, is guarded as trade secret, it is generally understood that lycopodium and tripoli form base.

Skip Hoist. Foundry Skip Hoist Saves Six Men. Iron Age, vol. 118, no. 3, July 15, 1926, pp. 139–141, 4 figs. Adaptation of blast-furnace design cuts labor cost in half; daily melt is increased and safety made primary consideration.

FUELS

Carbon Monoxide and Hydrogen, from. Synthetic Fuel From Carbon Monoxide and Hydrogen, O. C. Elvins and A. W. Nash. Fuel, vol. 5, no. 6, June 1926, pp. 263–265. Methods available for transformation of CO and H into compounds containing carbon and hydrogen are divided into four groups, all requiring use of catalyst and increased temperature.

Low-Grade. Using Low-Grade Fuel (L'utilisation des combustibles minéraux de qualité inférieure), M. Berthelot. Société des Ingénieurs Civils de France—Memories et Compte Rendu des Travaux, vol. 79, no. 5–6, May–June 1926, pp. 318–369, 9 figs. Fuels of high water and ash content. Alpine anthracite, lignites, dusts, sludges, etc.; design of improved furnaces for firing them; ash-fusion gas producers; coal washing by flotation; low-temperature carbonization; pulverized-coal firing; etc.

Moist. Combustion of Moist Fuel (Ueber das Verbrennen von feuchtem Heizmaterial), P. Pawlowitsch. Feuerungstechnik, vol. 14, nos. 14 and 15, Apr. 15 and May 1, 1926, pp. 165–169 and 180–182, 10 figs. Possible and actual heat effect of wood fuel, combustion temperatures, heat losses in flue gases, coefficients of efficiency of boiler, steam-forming effect in relation to moisture in wood; relation of heating surface of boiler to moisture of fuel; best utilization of moist fuel without preliminary in specially constructed furnaces; examples of such furnaces; furnace of author's design; conditions relating to utilization of low-grade fuels in Europe and in United States.

(See also OIL FUEL; PULVERIZED COAL.)

FURNACES, ANNEALING

Lining. New Furnace Lining, R. Walker. Iron Age, vol. 118, no. 7, Aug. 12, 1926, p. 420, 2 figs. Monolithic structure replaces brickwork; method of using.

FURNACES, GAS

Annealing. Bright Annealing by Gas Furnaces, J. B. Nealey. Iron Age, vol. 118, no. 7, Aug. 12, 1926, pp. 422–423, 3 figs. Making percolator parts in plant of Manning, Bowman & Co., Meriden, Conn.; air-gas ratio regulated to prevent scale formation.

Combustion-Space Requirements. Combustion Space Requirements, O. L. Kowalke and A. W. Carlson. Gas Age-Rec., vol. 58, no. 4, July 24, 1926, pp. 107–109, 5 figs. Behavior of burners attached to furnaces; maximum amount of gas which can be completely burned per unit volume of combustion space.

Melting. A New Incandescent High Temperature Melting Furnace. Metal Industry (Lond.), vol. 29, no. 3, July 16, 1926, pp. 60–61, 1 fig. Furnace designed for crucible melting of metals and alloys; it operates with town gas at ordinary main pressure and low-pressure air blast of only from 6 to 10-in. water gage, which is preheated.

FURNACES, HEATING

Fuel-Oil. Fuel Oil Furnace Burners for the Forge Shop, C. C. Hermann. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 47–49, 4 figs. In designing fuel-oil furnaces for heating forgings it is necessary to keep in mind high temperatures employed; introduction of excess air; use of baffle plate; ignition-chamber design; importance of thorough mixing; laying fireclay brick.

Fuels For. Fuels for Heat-treating Processes, M. Epstein. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 6–7, 2 figs. Discusses three heat-treating operations, each employing different type of heat energy, showing that each particular fuel has properties that fit it for certain work; operations described are elevator electric furnace; heat-treatment of malleable castings; Lavite process for annealing wire.

Reheating. A Direct Method of Calculating the Size of Continuous Re-Heating Furnaces, C. Gerrard. Iron & Coal Trades Rev., vol. 113, no. 3044, July 2, 1926, p. 3. Input to furnace; output; method of calculating furnace size.

FURNACES, INDUSTRIAL

Improvements. Recent Progress in Firing Industrial Furnaces (Les récents progrès réalisés dans le chauffage des fours industriels), M. Hardy. Technique Moderne, vol. 18, no. 13, July 1, 1926, pp. 385–394, 12 figs. Details of gas producers, Siemens, automatic, water-gas, etc.; furnaces for pulverized coal; heating furnaces, open-hearth, annealing; glass and other furnaces; replacing manual labor by mechanical devices, and consequent increased upkeep.

G

GAS ENGINES

Natural Gas. Gas Engine Competes with Motor Drive. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, pp. 953–954, 3 figs. More than 500,000 hp. of gas engines in operation in southern California use as fuel natural gas as it comes from oil fields; most economical and satisfactory engines are slow-speed two- or four-cycle designed to use natural gas through medium of properly proportioned mixing boxes; gas engine shows saving in fuel costs.

GAS PRODUCERS

Peat and Lignite, for. An Italian Gas Producer for Peat and Lignite (Ein italienischer Grossraumgaser für Torf und Braunkohle), A. Faber. Feuerungstechnik, vol. 14, nos. 16 and 17, May 15 and June 1, 1926, pp. 189–191 and 202–204, 4 figs. Design and operation of hydraulically operated Ricci-Gozo producer; analyses, gas yield, heat balance, and efficiency of gasification of peat and lignite.

GAS TURBINES

Steels for. Internal Combustion Turbines, W. H. Johnson. Autocar, vol. 57, no. 1604, July 30, 1926, pp. 165–166. Points out that solution of problem lies in discovery of suitable steels to withstand very high temperatures generated; recent development of new high-temperature steel by Hadfield concern may be of far-reaching importance to automobile industry by bringing gas turbine within bounds of practicable possibility.

GASES

Expansion. The Joule-Thomson Effect in Expansion of Gases (L'effet Joule-Thomson dans la détente des Gaz), J. Barbaudy. Revue générale des Sciences, vol. 37, no. 11, June 15, 1926, pp. 325–332, 11 figs. Reviews researches of Kelvin, Bradley and Hale, Vogel and others to determine effect of expansion of gases; relation between drop of temperature and drop of pressure during expansion, coefficient of expansion, expansion in Linde's method of liquefying air, etc.

GASOLINE

Cracking Process. Antiknock Motor Fuels by Cracking Shale Oils, J. C. Morrell and G. Egloff. Indus. & Eng. Chem., vol. 18, no. 8, Aug. 1926, pp. 801–802. Shale oils of American, Australian, and French origin have been cracked into yields of gasoline in excess of 50 per cent, based upon charging oil; chemical analysis of cracked gasoline indicates it to have high anti-knock properties as motor fuel; methods of treating cracked distillate obtained from cracking of shale oil to produce water-white sweet-odored and stable product.

GEAR CUTTING

Hobbing and End-Milling Machines. Hobbing and End-Milling Gear-Cutting Machine. Engineering, vol. 122, no. 3161, Aug. 13, 1926, pp. 193–194, 18 figs. part on supp. plates. Machine of somewhat special character constructed by Power Plant Co., West Drayton, Middlesex, for factory in Russia; it can be used for cutting double helical, triple helical, or straight teeth for producing worms and spiral gears and for scrolling sugar-mills or other types of rolls.

GEARS

Automobile. The Institution of Automobile Engineers, H. E. Merritt. Automobile Engr., vol. 16, no. 217, July 1926, pp. 266–274, 15 figs. Camshaft drives; pump gears; gear box; calculations of velocities of sliding and rolling; influence of rolling and sliding on lubrication; final drive; worm drive. Paper awarded Daimler premium for 1924–25.

Friction. Friction and Wear and Tear of Gears (Reibung und Abnutzung von Zahnrädern), K. Kutzbach. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 30, July 24, 1926, pp. 999–1003, 14 figs. Report on tests of Zahnräderfabrik Friedrichshafen. Measurement of loss in gears; comparison of energy-passage and energy-circuit method; tests of tooth friction give insight into behavior of different shapes of teeth, and limits of permissible load.

Helical. Solving a Helical Gear Problem by Unconventional Methods, E. Buckingham. Am. Mach., vol. 65, no. 8, Aug. 19, 1926, pp. 327–328. Selection of change gears without use of continuous fractions; calculation of theoretical pitch radius for hob and root radius of gear.

Hydromechanical. Hydro-Mechanical Marine Gearing, J. Richardson. North-East Coast Instn. Engrs. and Shipbldrs.—advance paper, for mtg., Apr. 9, 1926, pp. 301–314, 6 figs. Design, construction, and operation of vacuum oil clutch.

Instrument. Die and Assembling Fixture for Instrument Gears. Machy. (Lond.), vol. 28, no. 719, July 22, 1926, pp. 456–458, 6 figs. In manufacture of certain delicate recording instruments, it is necessary to employ gears of exceedingly fine pitch in trains having high gear ratios; friction is minimized partly by use of small delicate bearings and correspondingly small arbors for gears.

Stresses. The Influence of Elasticity and Errors in Tooth Shape on Stresses in Gears, J. E. Nicholas. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 893–898, 20 figs. Progress report of A.S.M.E. Special Research Committee on gears; determination of errors; load-velocity tests; effect of velocity on load; effect of elasticity of material, tooth form, and loads.

Teeth, Inaccuracy Measurement. Measuring Inaccuracy in Gear Teeth, J. L. Williamson. Can. Machy., vol. 36, no. 5, July 29, 1926, pp. 15–17, 7 figs. Discusses common errors in checking inaccuracies in gear tooth form and spacing and describes simple methods of determining errors. Paper read before Am. Gear Mfrs.' Assn.

Teeth, Strength of. Strength of Gear Teeth is Greatly Affected by Fillet Radius, S. Timoshenko and R. V. Baud. Automotive Industries, vol. 55, no. 4, July 22, 1926, pp. 138–142, 9 figs. Experiments made on gear-tooth models of celluloid by means of photo-elastic methods show that there is concentration of stress at fillet greater than result given by beam formula. Paper presented before Am. Gear Mfrs.' Assn.

GRINDING

Cams. Automobile Camshaft Grinding and Checking. E. W. Hancock. Machy. (Lond.), vol. 28, no. 720, July 29, 1926, pp. 493–497, 7 figs. Method of accurate cam grinding suitable to policy which has moderate output and variety of designs.

Crankshafts. Accurate Crankshaft Grinding, O. A. Knight and H. O. Hedlund. Abrasive Industries, vol. 7, no. 8, Aug. 1926, pp. 256–260, 7 figs. Various methods followed in crankshaft grinding, wheel selection; special machine balances shaft.

Internal. Internal Grinding, H. Darbyshire. Automobile Engr., vol. 16, no. 217, July 1926, pp. 254–255, 3 figs. Measures to be observed in securing accurate work and high output.

GRINDING MACHINES

Gear-Tooth. Churchill Gear Tooth Grinding Machine. Machy. (Lond.), vol. 28, no. 718, July 15, 1926, pp. 435–438, 9 figs. Machine produced by Churchill Machine Tool Co., Manchester, England.

Internal. An Interesting Internal Grinder. Automobile Engr., vol. 16, no. 217, July 1926, p. 264, 1 fig. Full automatic machine made by Giddings & Lewis Machine Tool Co., Wisconsin.

Spherical. A New Spherical Grinding Machine. Brit. Machine Tool Eng., vol. 4, no. 40, July–Aug. 1926, pp. 448–450, 2 figs. Churchill spherical surface-grinding machine designed for production of extremely accurate spherical surfaces.

Types. No. 28 Double Spindle Disc Grinder. West. Machy. World, vol. 17, no. 7, July 1926, pp. 287–293, 16 figs. Descriptions of 18 grinders made by various companies.

H

HAMMERS

Pneumatic. 30-Cwt. Pneumatic Hammer. Mech. World, vol. 80, no. 2063, July 16, 1926, p. 43, 1 fig. Description of pneumatic forging hammer.

HARDNESS

Rockwell Test. Rockwell Hardness-Test Approved. Soc. Automotive Engrs.—Jl., vol. 19, no. 2, Aug. 1926, pp. 125–126. Principle of test recommended by subdivision of Soc. of Automotive Engrs. Standards Committee.

Testing. Hardness Testing. Automobile Engr., vol. 16, no. 218, Aug. 1926, pp. 288–289, 2 figs. Notes on limitations of current methods.

HEAT TRANSMISSION

Liquids. Heat Transmission in Dripping Liquids (Der Wärmeübergang in tropfbaren Flüssigkeiten), M. ten Bosch. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 27, July 3, 1926, pp. 911–914, 4 figs. Points out that for heat transmission in dripping fluids only empirical formulas exist, whereas for all elastic fluids there is a standard law; a characteristic function for dripping and elastic liquids is derived and its utility is exemplified by comparison with experimental values.

Ribs, Through. Heat Transmission through Ribs (Die Wärmeübertragung durch Rippen), E. Schmidt. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 26 and 28, June 26 and July 10, 1926, pp. 885–889 and 947–951, 15 figs. Numerical investigation to determine how dimensions and design of ribs affect heat transmission; differential equations for heat flow in ribs; cooling ribs of constant heat flow density; straight ribs of rectangular cross-section.

HEATING

France. An Outline of Heating Practice in France, A. Beaurrienne and M. Renoult. Am. Soc. of Heat. & Vent. Engrs.—Jl., vol. 32, no. 8, Aug. 1926, pp. 631–636. Summary of evolution of heating in France shows that most interesting progress has been made in use of steam turbines working on very low steam pressures, fitted on shaft of centrifugal pump of forced

hot-water heating plant, return water being heated partly by exhaust steam from turbine at atmospheric pressure and partly by live steam for high loads; central-station heating.

HEATING, GAS

Houses, Wind Effect. The Effect of Wind on Gas Fires (Das Haus im Windstrom), Kobbert. Gas- u. Wasserfach, vol. 69, no. 20, May 15, 1926, pp. 404-412, 33 figs.; also translated abstract in Gas World, vol. 85, no. 2190, July 24, 1926, p. 83, 1 fig. Author points out that in putting in gas fires particular conditions ought to be much more carefully studied than is usually the case; an isolated house in gale of wind has increased pressure on windward side and partial vacuum on opposite side; wind running parallel to open window produces partial vacuum in room; various cases are discussed in which products are led into corridor or under roof, with effect of various manipulations of windows; for large house with many fires differently situated, it may become necessary to supplement chimney draft by setting ventilating fan at work.

Radiating Heat. The Role of Radiating Heat in the Heating Effect of Gas Heaters (Ueber den Anteil der strahlenden Wärme an der Wärmewirkung von Gasheizungen), F. Hurdelbrink and R. Polenske. Gas- u. Wasserfach, vol. 69, no. 21, May 22, 1926, pp. 421-430, 9 figs. Method of determining heat radiated from given source to given distance and surface, and its experimental test with heating lamp, gas heater filled with refractories, and cast-iron stove.

HEATING, HOT-AIR

Flue-Gas Sampling. Principles of Design in Furnace Heating, A. M. Daniels. Sheet Metal Worker, vol. 17, no. 12, July 16, 1926, pp. 452-454, 10 figs. Combustion of coal; products of combustion; flue-gas analysis.

HEATING, HOT-WATER

Heat Losses. Cooling of Water in Pipes of Heating Plant (Il raffreddamento dell'acqua nelle tubazioni degli impianti a termosifone), A. Gini. Ingegneria, vol. 5, no. 5, Mar. 1926, pp. 164-168, 1 fig. Discusses piping for heating plants with little change in level, with distribution from lower level; calculation of area of radiators for each; heat losses in lower-level plants; etc.

HEATING, STEAM

Central. Fundamental Factors in District Steam Distribution. Heat. & Vent. Mag., vol. 23, no. 8, Aug. 1926, pp. 73-76, 3 figs. How to predetermine initial pressures, transmission-line location, and other elements to secure best results.

Plant. University of Rochester Installs New Heating Plant, J. W. Gavett, Jr. Power, vol. 64, no. 6, Aug. 10, 1926, pp. 192-194, 5 figs. Water-tube boilers supply high-pressure steam to buildings; complete set of measuring instruments installed; plant used as testing laboratory by engineering students.

HOTELS

Power Equipment. New Palmer House of Chicago. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, pp. 882-887, 12 figs. Modern power plant of 2580 b.hp.; saturated steam at 125 lb. per sq. in. is furnished by four 645-hp. Brunswick-Kroeschell Co. three-pass boilers, each served by Green chain-grate stoker with area of 165 sq. ft.; coal and ash-handling system; fire protection; CO_2 refrigeration system.

HOUSES

Miners. Miners' Dwelling Houses, H. E. Mitton. Colliery Guardian, vol. 132, no. 3419, July 9, 1926, pp. 75-77, 12 figs. Site; streets; houses; lighting; hot water; furnace.

HOUSING

Labor. Housing. Monthly Labor Rev., vol. 23, no. 1, July 1926, pp. 71-76, 1 fig. Volume of building construction, 1919 to 1925, New York housing law; housing situation in Germany, 1925.

HYDRAULIC GEARS

Variable-Speed. A Variable Speed, Reversible, Hydraulic Power Transmission. Am. Mach., vol. 65, no. 7, Aug. 12, 1926, pp. 287-291, 12 figs. Variable-speed device without toothed gearing; oil is transmitting medium; operates equally well in either direction; simple operations in manufacture; made by Waterbury Tool Co.

HYDRAULIC MACHINERY

Characteristic Coefficients. Characteristic Coefficients for Hydraulic Machines, B. Eck. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 949-950, 1 fig. Points out fundamental relationship existing between turbines, centrifugal pumps, airscrews, screw propellers, windmills, etc., and to derive non-dimensional coefficients related to characteristic speed from physical considerations.

HYDRAULIC TURBINES

Developments. Present State and Tendencies in Hydraulic-Turbine Construction (Les progrès, l'état actuel et les tendances de la construction des turbines hydrauliques), P. Cayère. Arts & Métiers, vols. 78 and 79, nos. 58, 59, 64, and 65, July and Aug. 1925 and Jan. and Feb. 1926, pp. 269-286, 318-327, 11-24 and 63-67, 57 figs. Discusses general developments in turbine construction, to improve efficiency and reduce cost of installation; turbine theories and their application; similitude of turbines and its theory; classification by similitude; experiments with laboratory methods; Frances & Pelton turbines; systematic classification and application of results.

Draft Tubes. Draft Tube Lined with Cast Iron at Big Creek No. 8 Plant. Eng. News-Rec., vol. 97, no. 5, July 29, 1926, pp. 182-183, 2 figs. Lining of steel plates, loosened by vibration, is replaced by heavier construction in California hydro plant.

Governors. Hydraulic-Turbine Governor Pressure Fluids, M. B. Thurston. Power, vol. 64, no. 7, Aug. 17, 1926, p. 248. Discusses what appears to be best for oil-pressure governor; author's preference is fairly light oil of good flash test, strength of film and stability.

Some Types of Acceleration Governors (Sur quelques types de régulateurs—accélérométriques), L. Barbillion. Industrie Electrique, vol. 35, no. 814, May 25, 1926, pp. 221-229, 16 figs. Discusses speed regulation of turbines driving alternators; tachometric, accelerometric, and mixed regulation; servo-motors, regulation of supply of oil pump; Escher-Wyss regulator and its operation.

A Water Turbine Governor. Elec. Rev., vol. 99, no. 2541, Aug. 6, 1926, pp. 209-210, 3 figs. New and simplified apparatus of Gilbert Gilkes & Co.

Helical. The Geometry of the Helical Water Turbine, N. Popoff. Engineering, vol. 122, no. 3160, Aug. 6, 1926, pp. 155-159, 13 figs. As result of investigation of analysis, author concludes that theory of Lawaczeck, which leads to runner vanes in form of helical surfaces of special shape, with parabolic generating line in special case, is purely geometrical one, adaptable in combination with any hydromechanical theory; Lawaczeck has confirmed these conclusions as correct in principle and as coincident with his own.

Runners, Pitting of. Pitting of Hydraulic Turbine Runners. Elec. News, vol. 35, no. 15, Aug. 1, 1926, p. 40. Causes of this form of corrosion and methods for its prevention.

HYDROELECTRIC DEVELOPMENTS

Conowingo, Md. The Conowingo Project, Giant of Hydroelectric Developments. Engrs. and Eng., vol. 43, no. 7, July 15, 1926, pp. 194-195, 1 fig. Description of project of Philadelphia Elec. Power Co. which includes dam 4500 ft. long.

France. Hydroelectric Power on the Lower Isère, T. Rich. Elec. Rev., vol. 98, nos. 2531 and 2532, May 28 and June 4, 1926, pp. 795-798 and 827-828, 11 figs. First transmission in France at 120,000 volts; barrage 1440 ft. long is placed across river; it has six openings; sluice gates are of Storey type; station is equipped with seven turbine sets of vertical Francis type made by Neyret-Beylier and Piccard-Pictet; set-up transformers. June 4: Transmission line; insulators and conductors.

Newfoundland. The Humber Development of Newfoundland Power and Paper Company, Limited, H. C. Brown. Eng. Jl., vol. 9, no. 8, Aug. 1926, pp. 359-372, 22 figs. Power equipment and development and its installation in paper mill in Newfoundland; investigation of precipitation and flood conditions; canal and canal intake works; pipe line, power house and transmission lines, substation, switchboard room, conduit system, wire and cable.

Russia. Russian Plans for Dnieper River Hydro-Electric Development, L. H. Bauer. Elec. World, vol. 88, no. 5, July 31, 1926, p. 220. German conception of Ukraine project; additional information, from European angle, on work now in hands of American engineers.

Tasmania. Water Power and Hydro-Electric Development in Tasmania. Elec. World, vol. 88, no. 7, Aug. 14, 1926, p. 323. Hydroelectric development of Tasmanian government controls three of power undertakings: Waddamana scheme, Electrona Carbide Works and small 1500-hp. plant of Launceston Corp.

HYDROELECTRIC PLANTS

France. The Hydroelectric Plant at Eguzon on the Creuse and the Electrification of the Orléans Railway (L'usine hydro-électrique d'Eguzon et l'électrification des chemins de fer de la Compagnie d'Orléans), C. Dantin. Génie Civil, vol. 89, no. 1, July 3, 1926, pp. 1-10, 20 figs. 75,000-hp. plant at base of a dam 200 ft. high, equipped with five 15,000-hp. Neyret-Beylier turbines of Francis type and five 12,500-kva. triphase alternators generating at 10,000 volts and a frequency of 50; description of dam, transmission line, etc.

Italy. Hydroelectric Plants in Cenischia Valley, Italy (Les installations hydroélectriques de la vallée du Cenischia), J. Reyval. Revue Générale de l'Electricité, vol. 19, nos. 18, 19, and 20, May 1, 8, and 15, 1926, pp. 697-706, 733-744, and 778-788, 54 figs. Fed by watersheds from slopes of Mont Cenis in north of Italy, Cenischia River supplies motive power to three interconnected hydroelectric plants with combined output of 80,000 kw. and anticipated production of 180,000,000 kw-hr. annually; first plant operates under head of 630 ft. with 3 Pelton-wheel-driven generators; 3 corresponding transformer banks step voltage up to 31,000 for transmission to second station at Venaus, whose 3 Pelton turbines operate under head of 3400 ft.; machines are totally enclosed and self-ventilated; third station at Susa is under construction.

Mechanical Equipment. Equipping the Water Power Plant, F. Johnstone-Taylor. Power House, vol. 19, nos. 4, 5 and 8, Feb. 20, Mar. 5, and Apr. 20, 1926, pp. 19-23, 19-21 and 29-31, 31 figs. Feb. 20: Sluices and other control apparatus. Mar. 5: Pipes and pipe line. Apr. 20: Valves and protective devices.

Norway. The Mörkfos-Solbergfos Hydroelectric Plant in Norway (Die Mörkfos-Solbergfosanlage in Norwegen), G. Landmark. Siemens-Zeit., vol. 6, no. 5, May 1926, pp. 213-219, 10 figs. Details of low-pressure plant with head of 17 m. in summer and 22 m. in winter; there are 13 turbines of 11,500 hp. each, they have vertical shafts, and have reached efficiency of 94.5 per cent; details of generators, transmission lines, switchgear, etc.

Pennsylvania. Wallenpaupack Hydro-Electric and 220-Kv. Transmission Development, A. E. Silver and A. C. Clougher. Elec. World, vol. 88, no. 4, July 24, 1926, pp. 159-169, 16 figs. Description of power station; construction features; detail data.

Quebec. Rapid Work on Gatineau Power Plants. Contract Rec., vol. 40, no. 31, Aug. 4, 1926, pp. 736-738, 11 figs. Details of storage dam at Lake Bascatong power houses at Farmers' Rapids and Chelsea Falls, and pulp and paper mill at East Templeton.

Safety in. Developing the Safety Habit in a Hydro-Electric Station, R. D. Shaub. Nat. Safety News, vol. 14, no. 2, Aug. 1926, pp. 11-13 and 18, 6 figs. Methods and precautions employed at Holtwood hydroelectric station, Pa.

Spartanburg, S. C. $1,350,000 Water Plant Completed at Spartanburg. Mfrs.' Rec., vol. 40, no. 3, July 22, 1926, pp. 82-84. Concrete dam 450 ft. long creates reservoir of 350 acres; hydroelectric plant built to utilize excess water made available.

Switzerland. Mühleberg Power Plant of the Bern Kraftwerke A.G. (Das Kraftwerk Mühleberg der Bernischen Kraftwerke A.G.), E. Meyer. Schweizerische Bauzeitung, vol. 87, nos. 22, 23, 24 and 25, May 29, June 5, 12, and 19, 1926, pp. 275-280, 287-291, 300-305 and 311-316, 52 figs. partly on supp. plates. Details of dam and reservoir for power house of eight units of 6000 kw. and maximum absorption capacity of 320 cu. m. per sec., using waters of Rivers Aare and Saane; building of bridges, weirs, etc.; power house; building containing switching plant, busbars, etc.; oil-storage plant; construction methods.

I

IMPACT TESTING

Fatigue under Repeated Stresses. Fatigue under Repeated Impact Stresses and Its Relation to the Dynamic Elastic Limit. Metallurgist (Supp. to Engineer, vol. 142, no. 3681), July 30, 1926, pp. 108-110, 3 figs. Review of paper, by G. Welter, published in Zeit. des Vereines deutscher Ingenieure, May 15, 1926, in which author discusses problem and gives results of tests conducted on specimens of steel, aluminum, copper, brass, aluminum alloys, magnesium alloy, and glass.

INDICATORS

Mean-Pressure. Mean Pressure Indicator, J. Geiger. Eng. Progress, vol. 7, no. 7, July 1926, pp. 181-183, 8 figs. In all reciprocating engines there exists simple relation between mean pressure referred to stroke and mean pressure referred to time; describes measuring instrument indicating both pressures directly.

INDUSTRIAL MANAGEMENT

Catalogs. Catalogs (Die Stückliste), W. Heinze. Maschinenbau, vol. 5, no. 14, July 15, 1926, pp. 649-653, 6 figs. Discusses use of list of goods manufactured at given shop, in which for each item details of all its parts are given, and for each part all specifications, etc., for production, recommending this list as sole reference for producers and buyers, its information being complete to satisfy all demands; examples of sheets with tabulation; for parts and for finished goods.

Flow of Work. Devices for Use in Continuous Assembly (Verwendung von Vorrichtungen im fliessenden Zusammenbau), H. Krippendorff. Maschinenbau, vol. 5, no. 14, July 15, 1926, pp. 664-667, 3 figs. Discusses flow sheets and continuous assembly, and resulting saving in time, space, and number of hands; use of suitable devices for assuring flow; examples from American machine-shop practice.

Human-Power Measurement. The Bedaux System in Rubber Factories. India Rubber World, vol. 74, no. 5, Aug. 1, 1926, pp. 257-258. System deals only with measurement of human power, without considering method or equipment, expressing in one common unit work done, and affording comparison of productive and waste effort.

Inventory Reduction. Packard Cuts Inventory in Quarter at Same Time Tripling Car Output, A. Macauley. Mfg. Industries, vol. 12, no. 2, Aug. 1926, pp. 89-94, 10 figs. Current inventories of cars and parts at Packard Motor Car Co. are kept down to only one-fourth of what were customary outlays for these purposes about six years ago.

Production Lots, Determining Proper Size of. Method of Finding Minimum-Cost Quantity in Manufacturing, R. C. Davis. Mfg. Industries, vol. 12, no. 2, Aug. 1926, pp. 129-131, 1 fig. Formulas for size of production lots. Continuation of article in Apr. 1925 issue of same journal. See reference in Eng. Index 1925, p. 400.

Taylor System. Results under Scientific Management, M. C. Herrmann. Mfg. Industries, vol. 12, no. 2, Aug. 1926, pp. 111-113. As result of 14 years' experience with Taylor methods, author finds they are eminently suitable and profitable for small plant as well as large, when correctly applied.

Taylor's Famous Testimony Before the Special House Committee. Taylor Society—Bul., vol. 11, nos. 3 and 4, June-Aug. 1926, pp. 95-196. Reprint of hearings before special Committee of House of Representatives to investigate the Taylor and other systems of shop management.

INDUSTRIAL PLANTS

Power and Heat Supply. Selecting a Power and Heat Supply for Industrial Plants. Mech. Eng., vol. 48, no. 8, Aug. 1926, pp. 806-807. Discussion of paper by M. K. Bryan, published in June 1926, issue of same journal.

Service Department. Johnson and Johnson Service Department, G. E. Hagemann. Mfg. Industries, vol. 12, nos. 1 and 2, July and Aug. 1926, pp. 27-30 and 107-110, 9 figs. Effective method of handling plant maintenance and employee service.

INDUSTRIAL RELATIONS

Commonwealth Edison Co., Chicago, Ill. Some

Phases of Industrial Relations, H. E. Niesz. West. Soc. of Engrs.—Jl., vol. 31, no. 6, June 1926, pp. 251–258. Organization and function of Industrial Relations Department, Chicago, Ill., Commonwealth Edison Co.

Small Plants. Plans for Industrial Relations Work in Small Plants, R. W. Kelly. Mfg. Industries, vol. 12, no. 2, Aug. 1926, p. 132. In Associated Oil Co. scattered divisions in producing fields have successfully developed plan of using so-called employment foremen.

Street Railways. The Human Element in the Industry, F. G. Buffe. Elec. Ry. Jl., vol. 68, no. 4, July 24, 1926, pp. 145–147. Success is possible only with coöperation of men and management; men must be given full knowledge of aims and purpose of company if loyalty is to expected of them; results in Kansas City show it can be done.

INSULATION, HEAT

Industrial Applications. Heat Insulation in Industrial Plants, L. B. McMillan. Engrs. and Eng., vol. 43, no. 7, July 15, 1926, pp. 191–194, 5 figs. Observed conditions; useful curves; effect of circulating air; maintaining temperature head.

INTERNAL-COMBUSTION ENGINES

Friction Losses. Research on Friction Losses in Explosion Engines (Recherches sur les pertes par frottement dans les moteurs à explosions), A. Planiol. Technique Automobile et Aérienne, vol. 17, nos. 133 and 134, 1926, pp. 33–42 and 81–90, 18 figs. Experiments carried out to determine any connections between phenomena of internal friction in explosion engines, whether losses increase with power and velocity; study and operation of Watt indicators; variation of losses with charge; tests at variable speed and temperature.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

IRON

Corrosion. Note on the Protection of Iron by Cadmium, H. S. Rawdon. Metal Industry, (N. Y.), vol. 24, no. 7, July 1926, pp. 276–277, 3 figs. Relative electrode potentials; zinc, cadmium, iron; experiments; discussion and summary.

IRON, PIG

Blast-Furnace Temperature, Effect of. The Influence of Temperature in the Blast Furnace on Properties of Pig Iron (Die Einwirkung der Temperatur im Hochofen auf die Eigenschaften des Roheisens), A. Wagner. Stahl u. Eisen, vol. 46, no. 30, July 29, 1926, 1005–1012, 24 figs. partly on supp. plate. Different properties of pig-iron varieties of uniform composition and existing interpretation of their cause; chemical, physical and metallographic investigations of two experimental series, which were blown at different blast temperatures; evaluation of results; difference between coke and charcoal pig iron; importance of quantity and composition of slag.

J

JOINTS

Welded, X-Ray Examination. Welded Joints Searched by X-Rays, J. T. Norton. Iron Age, vol. 118, no. 7, Aug. 12, 1926, pp. 409–412, 9 figs. Defects which can be detected and some which cannot; methods of making and testing welds; typical radiographs.

K

KNITTING

Principles. Principles of Knit Fabric Production, M. C. Miller. Textile World, vol. 70, no. 4, July 24, 1926, pp. 53–57, 10 figs. Spring-needle knitting; how yarn feeding affects appearance of fabric; operation of sinkers, pressers, and web holders during yarn knitting, pressing, and needle drawing; needle construction; crystallizing and fatiguing of hook and beard; points to be noted in inspection of needles.

L

LABOR

Productivity Indexes. Index of Productivity of Labor in the Steel, Automobile, Shoe and Paper Industries. Monthly Labor Rev., vol. 23, no. 1, July 1926, pp. 1–19. First of series of studies of labor-productivity indexes in American industry now being carried on by U. S. Bur. of Labor Statistics.

Wages and Hours. Wages and Hours of Labor. Monthly Labor Rev., vol. 23, no. 1, July 1926, pp. 38–40. Wages and labor conditions in Louisiana; English views of American wage policies; wage fixing and wage rates in New South Wales; wages and prices in Cuba; average daily wages and output in French coal mines, 1920–1925; wages and cost of living in Nagarit, Mexico.

LABORATORIES

Hydraulic. New Hydraulic Laboratory for Worcester Polytechnic. Eng. News-Rec., vol. 97, no. 3, July 15, 1926, pp. 96–97, 3 figs. Small laboratory built in 1894 replaced by much larger one; provisions made for many kinds of tests.

LADDERS

Iron. Iron Ladders: Some Notes on Design and Construction, H. Atkin. Mech. World, vol. 80, no. 2063, July 16, 1926, p. 48, 4 figs. Supports for wall ladders; sections to employ; ladder rungs; assembly; finish.

LAPPING

Machines for. New Machine Eliminates Hand-Lapping of Crankshafts. Automotive Industries, vol. 55, no. 2, July 8, 1926, pp. 48–49, 2 figs. Does work of two to six men with greater precision; all line and rod bearings lapped simultaneously; single operator able to handle machines due to automatic timing feature.

LATHES

Crankshaft. Special High-Efficiency Lathe for Crankshafts (Spezial-Hochleistungsdrehbank für gekröpfte Kurbelwellen), O. Weil. Praktischer Maschinen-Konstrukteur, vol. 59, no. 19–20, May 15, 1926, pp. 191–196, 5 figs. New Schiess-Defries type of lathe for multi-throw crankshafts; simultaneous turning of crankshafts with 4 tools, requires 15–20 hp. for drive.

Single-Spindle. New Gridley Single-Spindle Automatic. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 59–60, 4 figs. Improvements recently made in Gridley single-spindle automatic turret lathe increase its power so that it is possible to use speeds and feeds which take full advantage of latest metal-cutting materials and tooling methods.

Turret. Improved Combination Turret Lathe. Engineer, vol. 142, no. 3680, July 23, 1926, pp. 96–97, 7 figs. Improved, all-geared combination turret lathe, equipped with four-jaw independent chuck and suitable for general chucking work.

The Turret Lathe in the Steel Mill. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 45–46, 4 figs. Economical use of turret lathe in machining only one or two parts of a kind.

Types. Lathes and Turret Lathes. West. Machy. World, vol. 17, no. 7, July 1926. pp. 297–301, 11 figs. Descriptions of 8 lathes and turret lathes made by various manufacturers.

LIGNITE

Boiler Firing. Converting a Fine-Paper Factory to Lignite Firing and Waste-Steam Utilization (Umstellung einer Feinpapierfabrik auf Braunkohlenfeuerung und Abdampfverwertung und die hierdurch erzielte Ersparnis), R. Hopp, Jr. Wärme- u. Kälte-Technik, vol. 28, nos. 11 and 12, June 2 and 16, 1926, pp. 119–120 and 137–139, 11 figs. Describes old and new boiler plant, change mainly due to lower price of lignite; steam consumption of factory before and after change, itemized saving effected.

Distillation. The Lurgi Process for Distillation of Lignite (Das Lurgi-Verfahren zur Schwelung von Braunkohle), Oetken and Hubmann. Wärme, vol. 49, no. 26, June 25, 1926, pp. 455–457, 4 figs. Development of low-temperature process and principles underlying it; description of retort and operating results.

Drying. Determination of Water Content of Dry Coal in Lignite Drying (Die Ermittlung des Wassergehaltes der Trockenkohle bei der Braunkohlentrocknung), K. d'Huart. Feuerungstechnik, vol. 14, no. 18, June 15, 1926, pp. 213–214, 3 figs. Cites example showing difficulty in obtaining a good average specimen for determining water content in dry lignite.

Smokeless Fuel from. "Karburit" a Smokeless Lump-Fuel from Lignite (Karburit, ein stückiger rauchloser Brennstoff aus Braunkohle), M. Dolch. Braunkohle, vol. 25, nos. 10 and 11, June 5 and 12, 1926, pp. 217–220 and 230–234. Describes Delkeskamp's process for producing Karburit from lignite and other coal, low-temperature process separating moisture and noncombustibles; analysis of product obtained with various types of coals; calorific value of karburit and similar fuels.

LINOLEUM

Manufacture. The Manufacture of Linoleum (La fabrication du linoleum). Génie Civil, vol. 89, nos. 2 and 3, July 10 and 17, 1926, pp. 34–37 and 49–53, 14 figs. July 10: Oxidation of linseed oil; preparation of cement composed of linseed-oil skins, Kauri gum and resin; pulverizing the cork; mixing of ingredients and their application to cloth; finishing and drying product. July 17: Machines for printing linoleum, rotary, automatic, semi-automatic, etc.

LOCOMOTIVE BOILERS

Feedwater Preheating. Experiments with Preheating Locomotive Feedwater (Esperimenti con preriscaldatori d'acqua per locomotive), Rivista Tecnica delle Ferrovie Italiane, vol. 29, no. 15, Mar. 15, 1926, pp. 181–213, 10 figs. Tests carried out by Italian State Railways with various types of preheaters, including those by Weir, Worthington, Knorr, Davies & Metcalfe, A. C. F. I. and Friedmann; their fuel consumption, efficiency; etc.

LOCOMOTIVES

Diesel-Electric. Diesel-Electric Locomotive Built in Russia. Ry. Age, vol. 81, no. 5, July 31, 1926, pp. 208–209. Locomotive weighing 198 tons, including fuel and water, driven by 1000-hp. engine.

1000-H.P. Diesel-Electric Locomotive. Engineering, vol. 122, no. 3159, July 30, 1926, pp. 150–152, 6 figs. Locomotive built by Baldwin Locomotive Works, Philadelphia; results of tests.

Garratt. British Engines for Chilean Railways. Ry. Rev., vol. 79, no. 4, July 24, 1926, pp. 129, 1 fig. Largest Garratt-type locomotives constructed thus far for use on Iquique-Carpas section.

German States Railways. Standard Locomotives for the German State Railways. Ry. Engr., vol. 47, no. 559, Aug. 1926, pp. 279–285, 8 figs. New high-powered 4-6-2 passenger and 2-10-0 freight engines of advanced design.

Mountain Type. The "Montana" Locomotives of the Northern Company (Las locomotoras "Montaña" de la Compañia del Norte), B. Costilla. Ingenieria y Construction, vol. 4, no. 42, June 1926, pp. 258–266, 3 figs. Operating tests of Hanomag 4-8-2 type locomotives for express trains between Madrid and Hendaya.

Oil-Electric. Russian Oil-Electric Locomotive of 1000 Hp. Oil Engine Power, vol. 5, no. 8, Aug. 1926, pp. 490 and 495–497, 3 figs. Has 10-cylinder airless injection engine; motors with thermocouples and ball-bearing axles.

3-Cylinder. A New Type of Locomotive in America. Ry. Gaz., vol. 45, no. 3, July 16, 1926, p. 74. Description of Union Pacific's 3-cylinder locomotive built by American Locomotive Co.

Valve Diagrams for. Valve Diagrams for Locomotives. Ry. Engr., vol. 47, no. 559, Aug. 1926, pp. 290–291, 3 figs. Points out that use of Zeuner, or other valve diagram, for purpose of design is not so usual, due perhaps to fact that certain amount of rather troublesome "trial and error" work is usually involved; author seeks to find more direct way of working.

LUBRICATING OILS

Distillation. The Distillation of Lubricating Oils under High Vacuum, B. T. Brooks. Ind. & Eng. Chem., vol. 18, no. 8, Aug. 1926, pp. 789–793, 4 figs. Reviews early practice and discusses work of Steinschneider in Europe; Schulze has recently shown that by adapting welding practice and by use of latest improved vacuum pumps, distillation on commercial scale can be carried out under absolute pressure of 3 mm.; properties of these distillates and general features of process.

Fire-Point Carbon Test. Fire-Point Carbon Test, R. M. Byrd and F. C. Vilbrandt. Ind. & Eng. Chem., vol. 18, no. 7, July 1926, pp. 699–701. This test, which consists of determining amount of residue formed upon heating oil to its fire point and diluting heated oil with gasoline, measures tendency toward oxidation of lubricating oils; no special or elaborate equipment is needed and its execution is simple and rapid.

Mid-Continent. The Composition of Midcontinent Petroleum, C. F. Mabery. Ind. & Eng. Chem. vol. 18, no. 8, Aug. 1926, pp. 814–819. Explains improvements in solvent fractionation; most of lubricants undergo vacuum distillation without great decomposition; behavior of petroleum lubricants on standardized frictional testing machine shows comparative strength of individual molecules to resist breaking stress as indicated by appearance of smoke and final rupture.

Properties. Lubricating Oils (Généralités sur les huiles de graissage), R. Fillon. Bul. Technique du Bureau Veritas, vol. 5, nos. 5 and 6, May and June 1926, pp. 83–85 and 104–106. Examines mineral, vegetable and animal oils and greases; origin, manufacture, properties, flash point, freezing, emulsions, impurities, acidity, etc.

LUBRICATION

High-Speed Journals. Lubrication of High Speed Journals and the Properties of the Oil in Its Use, T. Hayashida. Soc. Mech. Engrs. (Japan)—Jl., vol. 29, no. 110, June 1926, pp. 319–373, 23 figs. Results of experiments on lubrication and lubricants. (In Japanese.)

Refrigerating Machinery. Cold Storage and Refrigeration-Machinery Lubrication. Lubrication, vol. 12, no. 7, July 1926, pp. 73–84, 21 figs. Discusses importance and systems of lubrication; selection of ammonia-compressor lubricants; control of oil supply; reclaiming of oil; lubrication of carbonic-anhydride compressors; sulphur-dioxide-machinery lubrication, etc.

Steam Cylinders. Fundamental Principles of Efficient Steam Cylinder Lubrication. Nat. Engr., vol. 30, no. 8, Aug. 1926, pp. 361–363. Essential requirements for effective cylinder lubrication; oil as piston-sealing medium; lubrication without friction or wear; reduction of oil consumption; service problems and performance records.

M

MACHINE TOOLS

Historical Notes. Pioneer Tools Serve Industry 150 Years. Can. Machy., vol. 36, no. 4, July 22, 1926, pp. 15–17, 5 figs. Machine tools at work in Soho foundry, Birmingham, Eng., after 150 years of continuous service.

Leipzig Fair, Germany. Machine Tools at the Leipzig Fair, Machy. (Lond.), vol. 28, nos. 708, 709, 710, 712, 713, 714, 715 and 718, Apr. 22, 29, May 20, June 3, 10, 17, 24 and July 15, pp. 115–118, 156, 183–185, 225–227, 263–265, 309–311, 328–329 and 428–430, 45 figs. Apr. 22: Automatic grinding machine for large milling-cutter heads built by Schiess-Defries of Düsseldorf. Apr. 29: Heavy-duty double-column drilling machine. May 20: Centerless grinding machine; universal tool-milling machine. June 3: New precision lathe; surface and spline-shaft grinding machine. June 10: New machines by J. E. Reinecker, Chemnitz. June 17: High-production crankshaft lathe. June 24: Traveling-head milling machine. July 15: Single and double spindle, horizontal and vertical milling machines.

Nut-Driving Machines. Nut-Driving Machine.

Machy. (Lond.), vol. 28, no. 719, July 22, 1926, pp. 469–470, 3 figs. Radial air-driven type for tightening nuts on railway trucks or removing them.

Replacement Policy. Getting the Most Out of Your Machine Tool Dollar, K. H. Condit. Am. Mach., vol. 65, no. 7, Aug. 12, 1926, pp. 269–271. Replacement policy of Hawthorne Works of Western Elec. Co. in Chicago.

MACHINERY

China. Old and New Machinery in China, F. A. Foster. Am. Mach., vol. 65, no. 8, Aug. 19, 1926, pp. 329–331, 8 figs. British and German machines predominate; cost of American machines generally prohibitive; man power still used in small shops; types of cupolas for melting iron.

Paris Show. Industrial Novelties at the Paris Show (Les nouveautés industrielles à la foire de Paris). Technique Moderne, vol. 18, no. 12, June 15, 1926, pp. 353–354. Details of exhibits and exhibitors in metallurgy, ferrous and non-ferrous metallurgy, foundry work, rolling, drawing, etc.; ball and roller bearings; machine tools for metals and wood; steam engines and internal-combustion engines; pumps and compressors; electric motors and appliances.

MACHINING METHODS

Boring and Drilling. Boring and Drilling Automobile Components. Machy. (Lond.), vol. 28, no. 718, July 15, 1926, pp. 431–432, 4 figs. Boring and drilling an automobile rear axle and differential cover.

Gear Case. Machining a Motor Cycle Three-Speed Gear Case. Machy. (Lond.), vol. 28, no. 721, Aug. 5, 1926, pp. 517–520, 9 figs. Methods employed at works of Scott Motor Cycle Co., Saltaire, Yorks.

Steel-Tool Cutting vs. Grinding. Steel Tool and Grinding Wheel (Stahlwerkzeug und Schleifscheibe), C. Krug. Maschinenbau, vol. 5, no. 13, July 1, 1926, pp. 601–604, 7 figs. Investigates for a given piece of work whether grinding or machining with a steel tool or cutter is the more economical.

MAGNESIUM

Castings. Casting Magnesium, Characteristics and Recent Progress (La fonderie de magnésium—ses particularités—ses récents progrés), R. de Fleury. Technique Moderne, vol. 18, no. 14, July 15, 1926, pp. 426–429. Discusses metallurgy of magnesium and its difficulties; concludes that German Griesheim Elektron Co., Italian Isotta Fraschini Co., and French Michel Co. have succeeded in industrial production of magnesium castings.

MALLEABLE CASTINGS

Black-Heart. "Shrink" in Black-Heart Malleable, C. Kluijtmans. Foundry Trade Jl., vol. 34, no. 520, Aug. 5, 1926, pp. 123–125, 9 figs. Points out that there are two kinds of shrinks, (1) those filled up with iron and showing in center of section a granular area surrounded, in white iron, by large crystals; and (2) those showing a hole and as a rule surrounded by rim of granular iron; hole due to shrink; photomicrographs.

MATERIALS

Resistance and Elasticity. Theory of Resistance of Materials Compared with Some Results of Electric Statics (Le teoria della resistenza dei materiali in confronto con alcuni risultati della statica elastica), G. Supino. Annali dei Lavori Pubblici, vol. 64, no. 4, Apr. 1926, pp. 230–243, 2 figs. Discusses theory of resistance based on laws of Hooke and Bernoulli, and mathematical theory of elasticity; application to problems of beams supported at both ends, and under uniform load, over whole length, and over part of their length only.

MATERIALS HANDLING

Cost Reduction. What Progress in Reducing Material Handling's $3,000,000,000 Cost? Factory, vol. 37, no. 2, Aug. 1926, pp. 205, 207–214, 268, 286, 288, 290, 292, and 294–295, 31 figs. Results of investigation; inquiry among recognized experts on different types of material handling to determine what are today most significant trends in practice; inquiry among several hundred manufacturers of material-handling equipment to discover what have been most interesting installations of present year; inquiry among executives in many industries; survey represents altogether 124 factories.

Equipment for Production Processes. Fixed Equipment for Production Processes, W. T. Spivey. Factory, vol. 37, no. 2, Aug. 1926, pp. 257–259, 6 figs. Final economy of standardized type; combining cranes, monorails, hoists, conveyors; progressive assembly.

Factories. Controlling Production Mechanically, W. F. Bailey. Can. Machy., vol. 36, no. 4, July 22, 1926, pp. 21–24, 9 figs. Mechanical handling methods used in Hoover Company's factory.

Industrial Plants. Handling Studies Pay in the Otis Plant, R. J. Pearson. Mfg. Industries, vol. 12, no. 2, Aug. 1926, pp. 115–120, 10 figs. Cranes and motor, electric and hand-lift trucks operate under comprehensive and completely organized schedule.

Mobile Equipment. Mobile Equipment—In, Out, and Through the Plant, H. J. Payne and F. L. Eidmann. Factory, vol. 37, no. 2, Aug. 1926, pp. 271–273 and 286, 8 figs. Shipment on skids is developing rapidly; in large number of new installations standardization on skid height of around 11 inches is to be found; use of higher skid makes possible ready interchange of load between standard hand-lift equipment and standard electric lift trucks.

Warehouses. Reducing Handling Costs in the Warehouse, G. F. Zimmer. Indus. Mgmt. (Lond.), vol. 13, no. 7, July 1926, pp. 299–304, 4 figs. Explains how economies may be effected in handling of cases and packages in warehouse by employment of modern conveying appliances.

Yard Haulage and Handling. Yard Haulage and Handling, T. F. Barbier. Factory, vol. 37, no. 2, Aug. 1926, pp. 245–247, 252 and 254, 8 figs. Deals with trailers, gas tractors, cranes, hoists, and railways.

METAL WORKING

Cold-Press Finishing. Cold-Press Finishing of Metal, E. V. Crane. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 899–906, 22 figs. Pressures in deforming metal; sizing of forgings and of castings; cold forging; coining, stamping and embossing; materials for dies; knuckle-joint presses; automatic feeds.

METALS

Bending. Tools and Machines for the Bending of Metals. Machy. (Lond.), vol. 28, no. 721, Aug. 5, 1926, pp. 509–515, 8 figs. Bending motor-armature coils; formers and formulas for former settings; bending machines for coils.

Casting Properties. Properties of Metals Having Important Bearing on Casting and Thermal Deformation (Die wissenschaftliche Erfassung einiger für das Giessen und die Warmverformung wichtiger Eigenschaften der Metalle), F. Sauerwald. Zeit. für Metallkunde, vol. 18, nos. 5 and 6, May and June 1926, pp. 137–142 and 193–195, 11 figs. Casting of metals; properties of liquid metals and alloys; internal friction, turbulent friction and surface tension; measurements of internal friction and surface tension; molecular state in molten metals and alloys.

Corrosion-Resisting. Corrosion-Resisting Materials for Chemical Plant Construction, A. Grounds. Indus. Chemist, vol. 2, no 18, July 1926, pp. 296–300, 5 figs. Notes on corrosion-resisting irons and steels, aluminum, etc.

Engineering. Present Tendencies in Engineering Materials, J. A. Mathews. Mech. Eng., vol 48, no. 8, Aug. 1926, pp. 791–794. Specifications and what they should embody; widening expanse of engineering requirements in materials; recent demands on steel metallurgist; applications of alloy steels.

Latent Heat of Fusion. Conclusions Concerning Latent Heat of Fusion and Melting Point of the Metals, H. Etherington. Chem. & Industry, vol. 45, no. 26, June 25, 1926, pp. 430–431, 1 fig.

Properties. Metals and Their Properties, T. Newton. Sheet Metal Worker, vol. 17, no. 14, Aug. 13, 1926, pp. 535 and 537. Conductivity; expansion and contraction; table of coefficients of linear expansion; surface expansion; expansion of volume; examples of expansion.

Protective Coatings. Protective Coatings for Metals, J. A. Aupperle. Blast Furnace & Steel Plant, vol. 14, nos. 6, 7 and 8, June, July and Aug., 1926, pp. 281–283, 322–325 and 341–343, and 357, 1 fig. Various methods for protecting metal surfaces against corrosion and oxidation. July: Theory of sherardizing; how precipitation of vapor on metal occurs; tin plate; schoop metal-spraying process; colorizing as protection to resist heat; powder process; dip process. Aug.: Nature of coating; asbestos-protected metal; red and black paint; vitreous enameled sheets.

Stress, Influence on Flow. Influence of Mean Principal Stress on the Flow of Iron, Copper and Nickel (Versuche über den Einfluss der mittleren Hauptspannung auf das Fliessen der Metalle Eisen, Kupfer und Nickel), W. Lode. Zeit. für Physik, vol. 36, no. 11–12, May 11, 1926, pp. 913–939, 12 figs. Experiments on tubes of iron, copper, and nickel subjected to tension and to internal pressure; discusses elastic limit, rate of flow, dependence of stress causing flow on nature of flow, and influence of mean principal stress on greatest difference of tension in plastic state.

Surface Flaws. A Method of Observing Flaws in Metal Surfaces and of Comparing the Conductivities of Metal Plates, E. W. Marchant and J. L. Miller. Instn. Elec. Engrs.—Jl., vol. 64, no. 355, July 1926, pp. 737–744, 9 figs. Principle of action of apparatus; design and method of use; experimental results.

MICROSCOPES

Industrial Uses. The Use of the Microscope in Industry, R. G. Guthrie. West. Soc. of Engrs.—Jl., vol. 31, no. 6, June 1926, pp. 215–225, 32 figs. Kinds of microscopes; application to study of treatment of metals.

MILLING

Railway Shops. Milling Operations in Railroad Shops. West. Machy. World, vol. 17, no. 7, July 1926, pp. 285–286, 6 figs. Reduction in time due to installation in railroad shop of modern milling machines for manufacture of rolling stock and replacement parts.

MILLING CUTTERS

Cylindrical. Metal Working with Cylindrical Cutter (Die Metallbearbeitung mittels Walzenfräser), F. Beckh. Maschinenbau, vol. 5, nos. 11 and 12, June 3 and 17, 1926, pp. 497–504 and 557–561, 49 figs. Experiments with working ingot steel of various strength; determines most favorable shapes of milling cutter and most economic cutting speeds from results obtained; concludes that for greatest efficiency large pitch and angle of teeth, large feeds, and ample cooling are essential.

MILLING MACHINES

Types. Milling Machines, West. Machy. World, vol. 17, no. 7, July 1926, pp. 294–296, 6 figs. Description of 6 milling machines by various manufacturers.

MOLDING METHODS

Machine Molding. Machine Molding Boiler Section Castings, R. F. Ringle. Can. Foundryman, vol. 17, no. 7, July 1926, p. 11. When production requirements demand casting of uniform metal thickness, with all fitting parts true to pattern, Weil McLain Co. has found machine molder casting incomparable.

MOLDS

Die-Casting. Some Features of Mould Design and Construction for Aluminium Die-casting in Gravity Dies, N. V. Pearson. Machy. (Lond.), vol. 28, no. 718, July 15, 1926, pp. 425–427, 6 figs. Drawings of examples of gravity dies for die casting.

Ingot, Manufacture. Large Ingot Mold Plant Opens in Central West. Foundry, vol. 54, no. 13, July 1, 1926, pp. 510–512, 7 figs. Methods and equipment employed in South Chicago plant of Valley Mould & Iron Corp.

Ingot, Wall Thickness. The Influence of Mold Wall Thickness, F. Leitner. Forging—Stamping—Heat Treating, vol. 12, no. 7, July 1926, pp. 245–247, 11 figs. Influence of primary crystallization and time of solidification are examined in three different mold sizes with decreasing wall thickness; medium-wall molds have advantage, giving better crystal development and are less expensive than heavy molds. Translated from Stahl u. Eisen, May 13, 1926, p. 629.

Permanent. Permanent Molds for Making Iron Castings, H. A. Schwartz. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 916–918. Particulars regarding method of oil-flow cooling that automatically maintains mold at temperature below that at which it will deteriorate.

MOLYBDENUM

Alloying Element, As. Molybdenum as an Alloying Element, J. D. Cutter. Blast Furnace & Steel Plant, vol. 14, no. 8, Aug. 1926, pp. 365–367. Heat-treated molybdenum steels possess high elastic limit, reduction of area and impact value and great durability when subjected to abrasive wear; occurrence and production of molybdenum.

MOTOR BUSES

Engine Requirements. Engine Requirements of Interurban Motorcoach Service, L. P. Kalb. Soc. Automotive Engrs.—Jl., vol. 19, no. 2, Aug. 1926, pp. 179–182, 2 figs. Analyzes requirements of engine for 29-passenger interurban motor bus as to piston displacement, accelerative ability of vehicle, fuel consumption, numer of cylinders, engine speed, and relation of horsepower available to power required to propel vehicle with various ratios.

Heating and Ventilating. The Heating and Ventilating of Motorcoaches, L. C. Josephs, Jr. Soc. Automotive Engrs —Jl., vol. 19, no. 2, Aug. 1926, pp. 173–178. Both systems should perform their functions efficiently in entirely unobtrusive manner; requirements of heating system include unobtrusiveness, protection of passengers from hot pipes and danger from fire, even distribution, and freedom from noise and fumes; sources and methods of heating.

MOTOR TRUCKS

All-Metal Bodies. Two Special All-Metal Truck Bodies. Sheet Metal Worker, vol. 17, no. 13, July 30, 1926, pp. 491 and 526, 2 figs. Racks and pop-bottle cases as made in Enid sheet metal shop.

Impact. Motor Truck Impact as Affected by Tires, Other Truck Factors, and Road Roughness, J. A. Buchanan and J. W. Reid. Pub. Roads, vol. 7, no. 4, June 1926, pp. 69–82, 46 figs. Report of coöperative tests by Bureau of Public Roads, Society of Automotive Engineers, and Rubber Assn. of America.

Thornycroft. The Rigid Six-Wheeled Thornycroft. Motor Transport, vol. 43, no. 1115, July 26, 1926, pp. 113–114, 3 figs. Particulars of 30- to 50-cwt. chassis.

N

NON-FERROUS METALS

Shops. The Birmingham Works of H. H. Vivian and Company, Limited. Foundry Trade Jl., vol. 34, no. 520, Aug. 5, 1926, pp. 111–114, 6 figs. Methods and equipment of works solely devoted to non-ferrous metal industry; present activities embrace solid-drawn brass tubes for locomotive boilers, condensers, etc.; solid-drawn copper tubes; rolled metal in copper and brass for motor engineering, stamping, spinning, etc.; wires in brass and copper, etc.; there are 5 foundries ranged in line of buildings, but otherwise self-contained shops each devoted to particular manufacture; electric drive has been adopted throughout.

NUTS

Strength Test. Tests with Nuts 0.8 of the Bolt Diameter in Thickness (Versuche mit 0,8 d hohen Muttern), K. Schimz. Maschinenbau, vol. 5, no. 12, June 17, 1926, pp. 552–554, 8 figs. Discusses jolting and breaking tests of bolts and nuts, decreasing thickness of nut, and applies results to nuts of 0.8 of bolt diameter.

O

OIL

Bibliography. Recent Articles on Petroleum and Allied Substances, H. Britton. U. S. Bur. of Mines, May 1926, 34 pp. History and geographic occurrence, geology and origin, properties, refining, production, utilization, etc.

Cracking. The Development of a Liquid-Phase Cracking Process, S. J. M. Auld and A. E. Dunstan. Ind. & Eng. Chem., vol. 18, no. 8, Aug. 1926, pp. 803–807, 5 figs. Deals with Auld, Dunstan, and Herring cracking process; fundamental principles upon which design of plant was based; problem of maintaining liquid phase; factors which operate for and against this state; mechanism of cracking; experiments to determine relationship between oil temperature, skin

temperature, and furnace temperature, so as to design heating arrangements of plant.

Refineries. The Refineries at Pechelbronn. Petroleum Times, vol. 16, no. 391, July 10, 1926, pp. 45–48, 3 figs. Review of progress made on petroleum fields in France; total refining capacity is now from 90,000 to 100,000 tons with 54 stills of total capacity of 2000 cu. m.; reservoir capacity is 25,000 tons.

Refining. Systematic Refining of Cracked Distillates, J. C. Morrell. Ind. & Eng. Chem., vol. 18, no. 7, July 1926, pp. 733–738, 2 figs. Chemical factors in refining.

OIL ENGINES

Fiat Hot-Bulb. New Fiat Hot-Bulb Engine. Mar. Engr. & Motorship Bldr., vol. 49, no. 588, Aug. 1926, pp. 293–294, 2 figs. Crankcase scavenging discarded in novel crosshead-type engine of small size and low rating.

Heat Transmission. Heat Transmission in Oil Engines, W. Nusselt. Mar. Engr. & Motorship Bldr., vol. 49, no. 588, Aug. 1926, pp. 301–303, 5 figs. Deduction of theoretical expression from actual tests.

Sketches and Working. Sketches and Working of Oil Engines. Motorship, vol. 11, no. 8, Aug. 1926, pp. 617–619 and 620, 2 figs. Fuel-injection methods as distinguishing characteristics; effect on economic status and technical characteristics.

OIL FUEL

Burners. Oil-Fuel Burning Systems. Mech. World, vol. 80, no. 2066, Aug. 6, 1926, pp. 103–110, 29 figs. Types of equipment on market may be broadly classified under three systems according to method of atomizing fuel; pressure or mechanical, compressed-air, and steam-jet system; describes number of leading types of oil-fuel burning apparatus.

Characteristics. The Liquid Fuel Question, F. Burgess. Machy. Market, no. 1341, July 16, 1926, pp. 21–22. Characteristics of fuel oil; advantages, disadvantages, and economy.

Diesel-Engine Plants. Fuel Supply of German Diesel-Engine Plants (Die Betriebsstoffversorgung der deutschen Grossdieselmotoren-Analgen), M. Gercke. Elektrizitätswirtschaft, vol. 25, nos. 409 and 410, May 2 and June 1, 1926, pp. 216–221 and 245–248. Production, consumption and prices of hydrocarbons; tar oil as fuel, its properties and value; American and Russian oils; mineral oils and customs tariff.

OPEN-HEARTH FURNACES

Temperature Measurement. Optical Temperature Measurement on Open-Hearth Furnace, B. M. Larsen and J. W. Campbell. Am. Inst. of Min. & Met. Engrs.—Trans., no. 1581-C, Aug. 1926, 15 pp., 6 figs. Possible errors in optical measurements; temperature gradients in walls and roof of melting chamber; differences between flame-off and flame-on optical readings; temperature distribution in melting chamber.

OXYACETYLENE WELDING

Alloy Steel. Gas Welding alloy Steels, G. L. Walker Welding Engr., vol. 11, no. 7, July 1926, pp. 28–30, 13 figs. How high-carbon steels and high-speed steels can be successfully welded; some applications of process.

Pipe. Pipe Welding for the Building Contractor, H. E. Wetzell. Acetylene Jl., vol. 28, no. 2, Aug. 1926, pp. 65–72 and 102, 18 figs. Deals with welding of water, gas and steam pipes used in building construction.

Copper. Copper Welding, S. W. Miller. Machy. (Lond.), vol. 28, no. 720, July 29, 1926, p. 483. Results of series of tests made by author on copper welding rods containing such deoxidizers as silicon, manganese, aluminum, phosphorus, and various combinations of them.

Tool Steel. Welding High Carbon Tool Steel and High Speed Steel with the Oxyacetylene Torch, G. L. Walker. Am. Welding Soc.—Jl., vol. 5, no. 7, July 1926, pp. 40–48, 13 figs. Rules to be observed.

P

PACKING

Crating. Crating Practice for British Workshop Products, I. Menteith. Indus. Mgmt. (Lond.), vol. 13, no. 7, July 1926, pp. 310–314, 4 figs. Describes efficient crating methods for British workshop products.

Department Organization. Organisation of the Packing Department, R. Wendorby. Indus. Mgmt. (Lond.), vol. 13, no. 7, July 1926, pp. 285–289, 6 figs. Shows how this department can be run at minimum expense while yielding maximum results.

Export, for. Packing for Export, A. Jacob. Indus. Mgmt. (Lond.), vol. 13, no 7, July 1926, pp. 278–282, 5 figs. Deals with packing to be used for consignments sent overseas; prevention of shrinkage; damp-proof case; styles of containers.

Fragile Goods. Obtaining Maximum Security in Packing Fragile Goods, L. A. R. Clausen-Thue. Indus. Mgmt. (Lond.), vol. 13, no. 7, July 1926, pp. 291–295, 2 figs. Methods employed in packing fragile goods in general use, such as pottery and glass, accumulators, rubber, watches and clocks, and wax models.

Machinery. Packing Machinery and Heavy Goods. Indus. Mgmt. (Lond.), vol. 13, no. 7, July 1926, pp. 318–322, 1 fig. Methods in use for packing such bulky articles as machinery, automobiles, airplanes, and power plants for home and overseas markets.

Problems. Good Packing as an Economic Factor in Production. Indus. Mgmt. (Lond.), vol. 13, no. 7, July 1926, pp. 270–274, 6 figs. Problems connected with packing of foodstuffs, articles for household use, medical and toilet preparations, and certain articles of clothing.

PAINTS

Lighting Value. Lighting Value of Paint in Industrial Plants, M. Luckiesh and E. W. Commery. Indus. Engr., vol. 84, no. 8, Aug. 1926, pp. 350–353, 4 figs. Reflection factor and other properties which affect its value, with pointers that will aid in using it most effectively.

PAPER MACHINERY

Roll Grinder. New Type Farrel Roll Grinder. Paper Mill, vol. 49, no. 30, July 24, 1926, p. 4, 3 figs. New type of roll grinder which reduces time from one-third to one-half that formerly required.

PATTERNMAKING

Pipe Work. Economies of Pipe Patterns, J. McLachlan. Can. Foundryman, vol. 17, no. 7, July 1926, pp. 16–17, 8 figs. Author stresses fact that work involved in patternmaking for pipe work in foundry is not as simple as patternmakers who have had no practical experience imagine; describes use of templets.

PATTERNS

Care of. The Care of Patterns, W. Dobbs. Foundry Trade Jl., vol. 34, no. 519, July 29, 1926, pp. 87–88, 2 figs. System adopted in small foundry, whose work was partly of outside-order type.

Mounting. Mounting Patterns Requires Varied Ingenuity, H. N. Tuttle. Foundry, vol. 54, nos. 11, 12 and 13, June 1, 15 and July 1, 1926, pp. 438–441, 479–482 and 521–522, 35 figs. Patterns are classified into three general types: match-plate patterns, rock-over machine patterns, and stripping-plate patterns; first is used chiefly for bench work, while rock-over and stripping-plate patterns are in general use for floor work; material for pattern plates; advantages of cast plate; gating patterns.

Plates. Pattern Plates, E. Ronceray. Foundry Trade Jl., vol. 34, no. 519, July 29, 1926, pp. 89–92, 12 figs. Methods of manufacturing pattern plates and coreboxes adopted by Etablissements Ph. Bonvillain & E. Ronceray, which include considerable number of improvements and apparatus to facilitate their use. Paper read before Czecho-Slovakian Foundrymen's Assn.

PIANOS

Design and Construction. Piano Construction as an Engineering Problem, W. B. White. West. Soc. of Engrs.—Jl., vol. 31, no. 6, June 1926, pp. 226–235. Laws of vibrating strings; tones and tone control; string tension; importance of wood; sounding board; touch mechanism of "action;" problems of piano industry.

PIPE

Fittings. New Standards in Piping and Fittings. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, pp. 950–953, 1 fig. Tentative standards for high pressure and temperature pipe flanges and flanged fittings now ready for adoption by sponsor organization.

Joints, Standardization. Standardization of German Screwed Pipe Couplings (Zur Normung der HNA-Rohrverschraubungen), Seide. Werft—Reederei—Hafen (Supp.), vol. 7, no. 10, May 22, 1926, pp. 23–24, 10 figs. Most common type of screwed sleeve couplings adopted are those with cone or ball stuffing boxes; prior to standardization cone angles varying between 17 and 60 deg. were in common use; diversity of type emphasized necessity for standardization; it was found that type adopted for cone couplings was capable of withstanding pressures of from 450 to 800 kg. per sq. cm., while for ball couplings pressures up to 300 kg. per sq. cm. were successfully withstood. See translated abstract in Mar. Engr. & Motorship Bldr., vol. 49, no. 588, Aug. 1926, p. 316.

Standard Sizes. Standard Wrought Iron and Steel Pipe Sizes. Am. Mach., vol. 65, no. 7, Aug. 12, 1926, p. 297. Reference-book sheet.

PIPE, CAST-IRON

Centrifugally Cast. Machine for Centrifugally Casting Iron Pipe (Note sur une machine à couler les tuyaux en moules métalliques, par centrifugation), C. Derulle. Fonderie Moderne, vol. 20, June 1926, pp. 138–140, 1 fig. Details of French machine which, it is said, will cast a length of pipe every 5 min.

Sand-Spun Cast-Iron Pipe Manufacture. Foundry Trade Jl., vol. 34, no. 517, July 15, 1926, pp. 45–52, 9 figs. Raw material; plant used; sand reclamation; facing molds; melting plant; chemical and physical control.

Horizontal Casting. Casting Standard Lengths of Pipe Horizontally, J. R. McWane. Water Wks. Eng., vol. 79, no. 15, Aug. 1, 1926, pp. 983–984. Emphasizes advantages of method of making cast-iron pipe horizontally, and employing green sand molds; new method is said to be entirely different from old. (Abstract.) Paper read before Am. Water Wks. Assn.

Manufacture. Modern Methods of Cast Iron Manufacture, T. E. Dimbleby. Junior Instn. Engrs.—Jl. and Rec. of Trans., vol. 36, part 10, July 1926, pp. 421–450, 19 figs. Vertical molding plant; pit with fast and stationary boxes; cores and coremaking; assembling, casting and stripping; mechanical production of molds; molding machines; ramming machines; making pipes in permanent iron molds; centrifugal process.

PISTONS

Aluminum and Magnesium Alloys, of. Pistons of Aluminum "Alpax" and Magnesium (Les pistons en aluminium, en alpax et en magnésium), R. de Fleury. Académie des Sciences—Comptes Rendus, vol. 182, no. 10, Mar. 8, 1926, pp. 628–630, 1 fig. Disadvantages of thin-walled pistons in regard to carbonization, overheating with consequent ill effects on scavenging and efficiency, and on necessary tolerances in diameter, of ribbed pistons in respect of high heat transfer to lubricant, and of thick pistons on account of their weight, are claimed to be overcome by design described, which is intended to be made in light metal; advantages accruing from use of aluminum and magnesium alloys are demonstrated by data on their thermal constants.

Internal-Combustion Engines. The Pistons of Internal Combustion Engines. Engineering, vol. 122, no. 3159, July 30, 1926, p. 142. As result of numerous experiments, it has become recognized that cooling of pistons takes place chiefly by heat conductivity through walls in contact with cylinders; theoretical shape of piston must be modified according to coefficient of heat conductivity of metal employed; enumerates advantages of proper cooling of piston heads.

PRESSURE VESSELS

Cylindrical. Calculation of Horizontal Cylindrical Vessels (Beitrag zur Berechnung liegender zylindrischer Behälter), G. Wirtz. Wärme, vol. 49, no. 25, June 18, 1926, pp. 433–437, 11 figs. Discusses problems of designing containers and their supports in cases where weights of cylinder and its contents are factors of chief importance, as, for example, in case of Ruths' storage cylinders; author investigates stresses in relatively thin shell due to its own weight and weight of lagging material, also stresses due to water and pressure inside vessel under various conditions of filling and pressure; net pressure is greatest when steam pressure is zero and when working pressure is reached.

Heads. The Design of Dished Heads of Pressure Vessels, S. W. Miller. Mech. Eng., vol. 48, no. 8, Aug. 1925, pp. 845–846, 5 figs. Experience of Union Carbide Corp. in naming pressure vessels for some of its subsidiaries; in design latest series of tanks, working fiber stress of 8000 lb. in shell and 9000 in heads was used, Pressure Vessel Code being followed except for these stresses; results of tests showed that only permanent distortions that occurred were in the heads.

PRESSWORK

Radio and Telephone Parts. Press Work on Radio and Telephone Parts, F. J. Oliver, Jr. Am. Mach., vol. 65, no. 8, Aug. 19, 1926, pp. 309–312, 11 figs. Tooling for rapid production of high-quality standardized parts; blanking, drawing, forming, and perforating operations are involved.

PRODUCER GAS

Detarring. Electric Detarring of Lignite Producer Gas (Die elektrische Entteerung des Braunkohlen-Generatorgases), H. Becker. Braunkohle, vol. 25, no. 9, May 29, 1926, pp. 189–195, 2 figs. Lurgi process based on Cottrell-Möller patent, and experiments carried out showing that, compared with usual centrifugal process, yield in tar is 30 per cent higher and gas is absolutely pure.

Furnaces for. Furnaces for Highly-Purified Producer Gas, K. Wentzel. Eng. Progress, vol. 7, no. 7, July 1926, pp. 179–180, 6 figs. Chemical purifying and desulphurizing of producer gas hitherto gave rise to difficulties owing to its acid character and tar vapors suspended in it; these difficulties have been overcome by addition of alkali to purifying mass and corresponding heating of latter; system developed by firm of Gafag in Frankfort, Germany.

PUBLIC UTILITIES

Financing of. Financing Public Utility Corporations, M. J. Insull. West. Soc. of Engrs.—Jl., vol. 31, no. 6, June 1926, pp. 235–242. Method of operation and necessity for so-called holding companies.

PULVERIZED COAL

Boiler Firing. Improvement in Pulverized-Coal Firing (Die Weiterentwicklung der Kohlenstaubfeuerung), Wintermeyer. Bergbau, vol. 39, no. 14, Apr. 8, 1926, pp. 205–208, 2 figs. Discusses use of pulverized coal as supplementary firing and describes Schuckert-Petri combined grate and pulverized firing.

Marine Boilers. Pulverized Fuel for Marine Boilers. Mar. Engr. & Motorship Bldr., vol. 49, no. 588, Aug. 1926, pp. 298–300, 1 fig. Experiments carried out with powdered coal as fuel under Scotch boiler; particulars of new British fuel; method of distillation which results in production of gas, "L. & N." oil, and "L. & N." fuel, from coal; "L. & N." process is method of low-temperature distillation developed by Sensible Heat Distillation Co., London.

Preparation Costs. Powdered Coal Costs in Factory Plant, F. L. Wolf. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, pp. 894–896, 5 figs. Ohio Brass Co. keeps detail records of coal-preparation costs.

Pulverizers. Pulverized-Coal Preparation in Central Stations (Kohlenstaubaufbereitung in Grosskraftwerken), C. Naske. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 26 and 28, June 26 and July 10, 1926, pp. 873–878 and 952–955, 22 figs. Main types of pulverizers; description of various installations completed or under construction; results of practical experiences.

Small Plants. Is Pulverized Coal Practical in Small Plants? H. C. Shields. Pit & Quarry, vol. 12, no. 8, July 21, 1926, pp 71–74. Special equipment needed; more than fine grinding necessary; large furnace areas not necessary; amount of oxygen important; tube mill; destructive flames eliminated.

PUMPS

Boiler-Feed. Selection and Operation of Modern Boiler Feed Equipment, C. L. Hubbard. Nat. Engr., vol. 30, no. 8, Aug. 1926, pp. 341–344, 6 figs. Types of boiler-feed pumps and their application for different operating conditions and service requirements; advantages and disadvantages of direct-acting power-driven, and centrifugal pumps for different services; characteristics of centrifugal pumps.

Gear. Gear Pump Capacities, H. Walker. Machy. (Lond.), vol. 28, no. 719, July 22, 1926, p. 451. Pre-

sents tables showing capacity factors of gear pumps of all sizes; capacity factor represents output in gallons per minute for one revolution of pump which has gears of unit face width.

Vacuum. Condensation Pump Acting on Medium Primary Vacua (Pompe à condensation fonctionnant sur vide primaire médiocre), L. Dunoyer. Académie des Sciences—Comptes Rendus, vol. 182, no. 11, Mar. 15, 1926, pp. 686–688, 1 fig. Pump is designed to operate on vacua of from 10 to 30 mm. of mercury and to be of minimum cost and fragility; it is constructed entirely of glass, and high vacuum is produced in two stages, mercury vapor passing through sloping injector nozzle into water-cooled space connected with primary vacuum providing first stage.

Return Line Vacuum Pump, J. J. Hayes. Domestic Eng. (Chicago), July 24, 1926, pp. 28–35 and 45, 7 figs. Steam-driven pump; selecting proper capacity; geared and belted pumps; automatic control; rotary type, low-pressure, steam-driven vacuum pump.

R

RAILWAY SHOPS

Hoisting Devices. New Railway Hoisting Devices (Ueber neuere Eisenbahn-Hebewinden), Selter. Glasers Annalen, vol. 98, no. 12, June 15, 1926, pp. 189–196, 11 figs. Describes various types of car and locomotive axle-lifting hoists and jacks, not only stationary but also provided with wheels for running on track.

REFRACTORIES

Boiler Ash, Effect of. Lignite Ash and Its Effect on Refractories (Die Brennstoffaschen, namentlich von Braunkohle, etc.), J. Herbing. Bergbau, vol. 39, nos. 23 and 24, June 10 and 17, 1926, pp. 351–355 and 369–373. Properties and analysis of ashes and of refractories used in furnaces; determination of melting point, behavior at high temperature, etc.; reciprocal mechanical and chemical action of ashes and refractories.

Gas Works. Requirements of Refractories for Manufactured Gas Plants, S. S. Cole. Am. Ceramic Soc.—Jl., vol. 9, no. 7, July 1926, pp. 462–473, 10 figs. Discusses requirements of refractories used in gas producers, water-gas sets, horizontal retorts, vertical retorts, and gas and coke ovens, with respect to specifications which material must necessarily meet to prevent failure of installations.

REFRIGERANTS

Hydrocarbon. Thermodynamic Properties of Butane, Isobutane, and Propane, L. I. Dana, A. C. Jenkins, J. N. Burdick and R. C. Timm. Refrig. Eng., vol. 12, no. 12, June 1926, pp. 387–404 and (discussion) 404–405, 20 figs. Investigation to determine experimentally physical properties of hydrocarbon refrigerants in region of saturation and over ranges of pressure and temperature which are required for refrigeration range.

REFRIGERATING MACHINES

Gas-Fired. Gas Refrigeration, N. T. Sellman. Gas Industry, vol. 26, no. 7, July 1926, pp. A-12–A-14 and (discussion) A-14–A-15. Claims that most gas machines developed to date are less noisy, less complicated and have fewer moving parts than electric ice machines; describes machine which is a small compact gas-fired refrigerating unit of absorption type and enumerates points which test on this machine will show.

Household-Type. Design Problems of the Household Type Refrigerating Machines, M. Lassen. Refrig. Eng., vol. 12, no. 12, June 1926, pp. 409–413 and 415, 1 fig. Outline of factors which must be considered in any well organized plan for developing small automatic refrigerating machine.

Improvements. Recent Improvements in Refrigerating Apparatus, F. Ophuls and G. A. Horne. Refrig. Eng., vol. 12, no. 12, June 1926, pp. 406–408 and 414–415. Authors' comment on discussion by T. Shipley on their paper presented at Fourth International Congress of Refrigeration in London, 1924, and published in this journal in May 1926.

Platen-Munters. The Platen-Munters Refrigerating Machine for Domestic Refrigeration (Machine à froid, Système Platen-Munters), J. Laval. Génie Civil, vol. 88, no. 26, June 26, 1926, pp. 567–568, 3 figs. Continuously functioning ammonia-absorption machine without moving parts, for domestic use; requires only a source of heat (electricity or gas) and a small flow of water, and consumes hourly but 300 watt-hours (or 2.8 cu. ft. of gas) and 6.6 gal. of water.

Diesel and Electric Drive. Comparison of the Electric and Diesel Drives for Ice Plants, C. T. Baker. Refrig. World, vol. 61, no. 7, July 1926, pp. 14–15. Basis for comparing relative merits of two systems of drive.

REFRIGERATION

Adsorption and. Adsorption and Its Relation to Refrigeration, F. G. Keyes. Refrig. Eng., vol. 12, no. 12, June 1926, pp. 416–417. Enumerates characteristics which adsorbent useful in refrigeration art must possess; aspect of problems encountered in connection with adsorbents and absorbents.

RIVERS

Circulating Water Intakes on. Circulating Water Intakes on Inland Rivers, C. E. Colborn. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, pp. 898–899, 4 figs. In absence of specific data, stratification of water in rivers must not be assumed.

RIVETED JOINTS

Elastic Behavior. Elastic Behavior of Riveted Joints (Elastisches Verhalten der Nietverbinbungen), E. Höhn. Zeit. des Bayerischen Revisions-Vereins, vol. 30, nos. 11 and 12, June 15 and 30, 1926, pp. 135–138 and 147–149, 18 figs. Details of experiments carried out for Swiss Steam Boiler Users Assn. with plates of 17 mm. and straps of 14 mm., plates of 30 mm. and straps of 22 mm., and rivet diameter of 18 to 24 and 30 to 24 mm.; relative displacements, direction of forces acting on rivets; stresses in riveted plate, internal and external displacement, etc. Extracts from "Nieten und Schweissen der Dampfkessel," Springer, Berlin.

ROLLING MILLS

Blooming Mills. World's Largest Blooming Mill Completed. Blast Furnace & Steel Plant, vol. 14, no. 8, Aug. 1926, pp. 358–360, 2 figs. Details on 54-in. two-high reversing blooming mill completed at Youngstown plant of United Eng. & Foundry Co. for Homestead Works of Carnegie Steel Co.

Tandem Drive. New Tandem Rolling Mill Control, P. B. Harwood. Elec. World, vol. 88, no. 5, July 31, 1926, pp. 223–224, 1 fig. Problem of speed differences between rolls to care for elongation of material solved; tandem to independent motor control easily accomplished.

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SAFETY

Electrical Hazards. Electrical Hazards and the Safe Use of Electrical Apparatus, F. A. Gaby. Elec. News, vol. 35, no. 14, July 15, 1926, pp. 32–34. Ontario Hydro Commission regulation to avoid danger from shock and fire.

Small-Plant Campaign. Organizing and Putting Across a Safety Campaign in a Small Plant, C. B. Auel. Safety Eng., vol. 52, no. 1, July 1926, pp. 37–41. Safety organization and education; supervisor of safety; departmental safety committees; program; physical examination of employees; Western Pennsylvania safety campaign; results.

U. S. Steel Corporation. Twenty Years of Safety—The United States Steel Corporation's Experience, A. C. Carruthers. Safety Eng., vol. 52, no. 1, July 1926, pp. 13–17, 12 figs. What has been accomplished; twofold benefits.

SAND, MOLDING

Facing Sands. A Practical View of Facing Sands. Foundry Trade Jl., vol. 34, no. 518, July 22, 1926, p. 79. Points out importance of mixing of facing sand; sands used in facings should be properly dried and then coal dust added; gives table of mixtures for various classes of moldings; rule of blackings in facing mold.

Permeability and Cohesion, Measurement of. Practical Use of Apparatus for Measuring Permeability and Cohesion of Molding Sand (Utilisation pratique des Appareils de mesure de la perméabilité et de la cohésion des sables de moulage), R. Lemoine. Fonderie Moderne, vol. 20, July 1926, pp. 155–162, 3 figs. Discusses mixtures for a given product, their composition and method of preparation; control of uniformity of materials for mixtures; control of mixtures to assure regularity of operations and uniformity of properties.

SCREW THREADS

Cutting Equipment. Thread Cutting Equipment. West. Machy. World, vol. 17, no. 7, July 1926, pp. 302–304, 4 figs. Descriptions of various threading machines, die heads, and taps.

SEAPLANES

German Competition. The German Seaplane Competition. Flight, vol. 18, nos. 29, 30 and 31, July 22, 29, and Aug. 5, 1926, pp. 448–452, 465–467 and 479–480, 12 figs. Description of machines entered for competition held at Warnemünde on Baltic, in order to encourage production of commercially efficient mail-carrying seaplanes. See also Aeroplane, vol. 31, no. 3, July 21, 1926, pp. 104–106 and 108, 6 figs.

Schneider Cup Race, 1925. The Schneider Cup Race, 1925, J. S. Buchanan. Roy. Aeronautical Soc.—Jl., vol. 30, no. 187, July 1926, pp. 434–443 and (discussion) 443–452, 3 figs. Particulars of racing seaplanes, suggestions for design in order to increase speed.

SEPARATORS

Steam. Saving Fuel by Using Dry Steam, F. Dawson. Eng. & Boiler House Rev., vol. 40, no. 2, Aug. 1926, pp. 67–70, 5 figs. Types of separators for eliminating moisture from steam.

SHEET IRON

Pickling. Some Factors Influencing the Rate of Pickling of Sheet Iron, J. E. Hansen and G. S. Lindsey. Am. Ceramic Soc.—Jl., vol. 9, no. 8, Aug. 1926, pp. 481–492, 13 figs. Results of experiments with regard to various factors entering into pickling of sheet iron.

SHEET METAL

Machines for Working. Equipment for Sheet Metal and Structural Fabrication. West. Machy. World, vol. 17, no. 7, July 1926, pp. 309–311, 8 figs. Description of various machines, shears, riveters, bending rolls, flanging machines, hammers, etc.

SHOVELS

Steel. The Steel Shovel—How it is Made, M. W. Von Bernewitz. Iron Age, vol. 118, no. 5, July 29, 1926, pp. 273–274. Features of mine and works shovel; types reduced by standardization; larger use of steel handles; proper way to shovel.

SMOKE

Air Pollution by. Calculating Distribution of Smoke and Waste Gases in the Atmosphere (Zur Berechnung der räumlichen Verteilung von Rauch und Abgasen in der freien Luft), W. Schmidt. Gesundheits-Ingenieur, vol. 49, no. 28, July 10, 1926, pp. 425–426, 1 fig. Method of calculating pollution of air by smoke from stacks, etc., for given height of stack and velocity of wind.

SOLAR ENGINES

Design Principles. Solar Engines, Remshardt Eng. Progress, vol. 7, no. 7, July 1926, pp. 185–189, 8 figs. General principles for design; explanation of refractory plant planned by Remshardt.

SPECIFIC SPEED

Propeller Theory, Relation to. The Nature of Specific Speed (Das Wesen der spezifischen Drehzahl), B. Eck. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 30, July 24, 1926, pp. 1015–1016, 1 fig. Determines relationship between specific speed and characteristic values of propeller theory, such as degree of load, degree of progress and thrust.

SPRINGS

Coil. Design of Coil Springs, L. F. Swenson. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 42–44, 2 figs. Formulas for strength, deflection, and size; slide rule for spring calculations.

Manufacture. Tools for Making Air Springs, F. C. Hudson. Am. Mach., vol. 65, no. 7, Aug. 12, 1926, pp. 283–284, 7 figs. Fixtures and methods that utilize standard machines as well as special devices for closing tube ends at single heat.

Valve. Valve Springs, A. Swan. Automobile Engr., vol. 16, no. 218, Aug. 1926, pp. 290–293, 10 figs. Surging and its effect on durability and functioning.

STACKS

Welded Steel. Welded Steel Stacks Avoid Corrosion at Joints. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, pp. 908–909, 5 figs. Guyed stacks built at shop and erected in one piece; self-supporting stacks built in place; both types are strong jointless steel cylinders.

STANDARDIZATION

Cost Reduction By. Standardization as a Cost Reducer, B. M. Smarr. Am. Mach., vol. 65, no. 9, Aug. 26, 1926, pp. 357–358. Appreciable savings are possible through standardization work within company; how best to get results; type of man needed for standards work.

STANDARDS

Austrian Oe. N. I. G. Reports. Report of Austrian Industrial Standards Committee (Normblattentwürfe). Sparwirtschaft, vol. 3, no. 7, July 1926, pp. N89–N92. Proposed standards for loads in building construction; including wind loads and snow loads; technical oils and fats (excluding liquid fuels); classification, definition, sampling.

German N. D. I. Reports. Report of German Industrial Standards Committee (NDI-Mitteilungen). Maschinenbau, vol. 5, no. 12, June 17, 1926, pp. 585–596, 15 figs. Proposed standards for round, flat, square, and hexagonal drawn copper; brass sheets and strips, rolled cold; seamless drawn brass tubes; round, flat, square, and hexagonal drawn and pressed brass; cylinders, cylinder knobs, keys, bells, etc., for typing machines; keys for automobile shaft keyways.

Report of the German Industrial Standards Committee (NDI-Mitteilungen). Maschinenbau, vol. 5, no. 13, July 1, 1926, pp. 637–639, 2 figs. Proposed standards for locksmith's and fitter's hammers (up to 2000 g. or 4.4 lb.) and sledges (2 to 10 kg. or 4.4 to 22 lb.).

STEAM

Behavior of Jet in Water. Behavior of a Jet of Steam in Water (Verhalten eines Dampfstrahles in Wasser), O. v. Mossin. Gesundheits-Ingenieur, vol. 49, No. 24, June 12, 1926, pp. 357–364, 21 figs. Discusses dynamic laws of simultaneous movement of liquids and gases, or aerohydraulics, either being medium; behavior or jets of steam in water to determine whether theoretical calculations are consistent with facts; results of experiments.

Supersaturated. The Theory of Supersaturated Steam, D. C. Turnbull, Jr. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 948–949. Origin of theory and experimental evidence in support of it.

STEAM PIPES

Expansion. Notes on Expansion of Steam and Hot Water Pipes, A. Lewis. Heat. & Vent. Mag., vol. 23, no. 8, Aug. 1926, pp. 61–64, 5 figs. With charts covering practice on high-pressure steam mains and hot-water piping. (Abstract.) Paper read before Victorian Inst. of Engrs.

STEAM POWER PLANT

Cement Mills. Modern Cement Plant Produces all Its Power from Waste Heat, T. M. Arnold. Power, vol. 64, no. 7, Aug. 17, 1926, pp. 232–235, 8 figs. Power plant consisting of three 10,480-sq. ft. boilers and 3000-kw. turbo-generator capacity operates on waste heat from cement kilns; at times steam produced in boilers exceeds requirements by about 50 per cent; evaporators and 35,000-gal. distilled-water storage are used to regulate heat cycle.

Diesel-Engined. In the Diesel Plant Operating Cost Outweigh Capital Charges, L. H. Morrison. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 326–327. Points out that overhead charges regardless of how calculated need not be determining factor in an industrial power plant, for there are other influences susceptible to control that are of equal or greater weight in arriving at total cost of power; facts were recently brought out in study of textile plant where Diesel engines were under consideration.

High-Pressure. Operating Experiences with a High-Pressure Steam Plant in the Austrian Textile Industry (Betriebserfahrungen bei einer Hochdruckdampfanlage in der Oesterreichischen Textilindustrie), W. Kuffler. Sparwirtschaft, vol. 3, no. 6, June 1926, pp. W91–W94, 4 figs. Describes satisfactory replacement of old plant of 4 steam engines, 8 boilers, and 21 hands by one steam turbine, two boilers and 5 hands per shift, and reduction of 500 cars of fuel per year; Brown-Boveri turbine of 1600-kw. capacity; Hanomag vertical boilers.

Sawdust-Burning. Sawdust Supplies Steam for Rockford Cabinet Co. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, pp. 936–940, 8 figs. Wood waste burned in new modern power plant of Rockford Cabinet Co., Rockford, Ill. gives high boiler ratings and makes company nearly independent of outside fuel.

STEAM TURBINES

Bleeder. Process of Bleeder-Steam Preheating (Verfahren der Anzapfdampf-Vorwärmung), W. G. Noack. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 30, July 24, 1926, pp. 1004–1010, 13 figs. Based on existing and planned installations, author describes processes of bleeder-steam preheating; bleeding of main turbines; use of special preheating turbines; bleeder-steam preheating in combination with economizers, waste-heat boilers, and steam accumulators.

Where To Bleed Turbine, W. G. Lauffer. Power, vol. 64, no. 10, Sept. 7, 1926, pp. 363–365, 6 figs. Author presents calculations and curves, showing how many stages steam should be bled to heat feedwater and which stages will give best economy.

Efficiencies. Notes on the Comparison of Steam Turbine Efficiencies, E. L. Robinson. Gen. Elec. Rev., vol. 29, no. 7, July 1926, pp. 503–510, 15 figs. Fundamental relations between efficiencies; reheat factor; condition curves; non-thermodynamic effects; percentage of heat recovery and economy.

Extraction. Extraction Turbine Fills Many Needs, S. B. Roberts. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, pp. 896–898, 8 figs. Installation of 1580-kva. mixed-pressure extraction unit effects considerable savings in industrial plant.

High-Pressure. Recoverable Heat in High-Pressure Steam Turbines (Die rückgewinnbare Wärme bei Hochdruckdampfturbinen), A. Wewerka. Archiv für Wärmewirtschaft, vol. 7, no. 7, July 1926, pp. 189–192, 5 figs. External losses; mechanical, stuffing-box, line, radiation and condensate; and internal losses; heat drop in throttling, friction and eddies in steam, heat radiation and transmission; recoverable heat, factor of recovery and its determination, formulas and curves for same.

STEEL

Heat-Resisting. Modern Heat-Resisting Steels. Mech. World, vol. 80, no. 2064, July 23, 1926, pp. 59–60, 2 figs. New "Era/HR" heat-resisting steel produced by Hadfields, Ltd., Sheffield, Eng., exceptional characteristic of which is its freedom from scaling combined with unusually great strength at high temperatures.

Hardening. The Hardening of Steel: A Review and Some Comments, W. T. Griffiths. Metallurgist (Supp. to Engineer, vol. 141, nos. 3665, 3670, 3672, and 3676), Mar. 26, Apr. 30, May 28, and June 25, 1926, pp. 34–36, 51–53, 72–74, and 89–90, 8 figs. Summary of existing information and review of more important papers on subject, with comments on main points as they arise; subject is dealt with chronologically as far as possible, in order to indicate how views at present held have been reached. Apr. 30: X-ray spectrographic examination. May 28: Troostite, martensite and austenite. June 25: Theories of cause of hardness of quenched steels. Bibliography.

High-Temperature Testing. Safe Stresses at High Temperatures. Metallurgist (Supp. to Engineer, vol. 142, no. 3681), July 30, 1926, pp. 104–106, 3 figs. Particulars of rated pressure of recent boiler installations; review of high-temperature tests, especially of work by Cournot and Sasagawa in Revue de Métallurgie, Dec. 1925, giving results for creep strength or viscosity limit relating to carbon steels, high-speed steel, silicon-chromium steel, and nickel-chromium alloy.

STEEL CASTINGS

German Developments. The Development of the German Steel-Casting Industry in the Past 25 Years (Die Entwickung der deutschen Stahlformguss-Industrie in den letzten 25 Yahren), R. Krieger. Stahl u. Eisen, vol. 46, nos. 21 and 26, May 27 and June 30, 1926, pp. 697–706 and 865–869, 21 figs. Development of Krieger steel works in Düsseldorf; technical improvements in steel molding, production and refining processes; increased use of steel castings during war; strength properties and their improvement through alloy additions; examples of utility and adaptability of steel castings.

Shrinkage Stress. Shrinkage Stress of Steel Castings in the Mold (Festigkeitsbeanspruchung von Stahlgussstücken beim Schwinden in der Gussform), H. Malzacher. Stahl u. Eisen, vol. 46, no. 30, July 29, 1926, pp. 1013–1017, 12 figs. Shrinkage load and shrinkage forces; results of shrinkage; means of reducing stress; practical examples.

STEEL, HEAT TREATMENT OF

Carbon Steels. Facts and Principles Concerning Steel and Heat Treatment, H. B. Knowlton. Am. Soc. Steel Treating—Trans., vol. 10, no. 2, Aug. 1926, pp. 285–298. Manufacture, properties and uses of plain carbon steels other than tool steels from standpoint of consumer; effect of different carbon contents upon properties of steel.

Chemical and Physical Considerations. Heat Treatment Practice. Automobile Engr., vol. 16, no. 217, July 1926, pp. 262–263. Thermal critical points of steel; annealing; hardening and tempering; alloy steels.

Gas as Fuel for. Gas as a Fuel for Heat Treating Metal, I. Ginsberg. Forging—Stamping—Heat Treating, vol. 12, no. 7, July 1926, pp. 250–252, 3 figs. Scope of industry great; efficient equipment results in economy; provisions for materials handling; most fuels essentially gaseous.

Gas Cylinders. The Heat Treatment of Gas Cylinders. Engineering, vol. 122, no. 3160, Aug. 6, 1926, pp. 184–185. Report, based on three series of experiments carried out at National Physical Laboratory, in order to determine effects of re-annealing and renormalizing overstrained specimens of 0.25 per cent and 0.45 per cent carbon steel.

STEEL, HIGH-SPEED

Heat Treatment, Effect of. Hardness and Toughness of High Speed Steel, R. K. Barry. Am. Soc. Steel Treating—Trans., vol. 10, no. 2, Aug. 1926, pp. 257–266, 10 figs. Physical properties of high-speed steel can be closely controlled by manner of heating, cooling, tempering, and drawing; results of tests covering heat treatment.

STEEL INDUSTRY

Brazil. Comparative Study of Cost of Iron Produced in Blast Furnaces with Various Fuels (Estudo comparativo do preco do ferro obtido no forno alto com diversos combustiveis), F. W. Freise. Revista Brasileira de Engenharia, vol. 11, no. 5, May 1926, pp. 180–182. Brazilian fuel and ore conditions, cost of producing coke, coal, lignite, etc.; coke vs. charcoal as fuel; blast-furnace cost data; Brazilian industry must have good, cheap, and constant supply of fuel to succeed.

STEEL MANUFACTURE

Bessemer Process. The Metallurgy of the Bessemer Process (Zur Kenntnis der Metallurgie der Windfrischverfahren) R. von Seth. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 29, July 17, 1926, pp. 973–979, 12 figs. Process of melting of Bessemer and Thomas charges based on metal, slag, and exhaust-gas tests; temperature measurements of metal, slag, and exhaust gas; heat balances of Thomas and Bessemer charges; phenomena in connection with converting; importance of carbon as heat producer in connection with blowing.

Chrome Steel. Production of High Chromium Alloy Steel, R. S. Kerns. Blast Furnace & Steel Plant, vol. 14, no. 8, Aug. 1926, pp. 334–336. Manufacture of high-chromium alloy steel in acid-lined furnace; with proper care, acid furnaces are as satisfactory as basic.

Rimmed. Rimmed Steel and How It Is Made, H. D. Hibbard. Iron Age, vol. 117, no. 25, June 24, 1926, pp. 1778–1780 and vol. 118, nos. 3 and 4, July 15 and 22, 1926, pp. 142–143 and 214–215. June 24: Products made from rimmed or effervescence steels; uses and properties; effervescence and skinholes. July 15: Melting-furnace practice; effect of manganese; intermediate and central holes. July 22: Character of slags and casting temperatures; scums and what they indicate; extent of segregation.

STEEL WORKS

Inland Steel Co., Indiana. A Large American Steel Works—Description of the Indiana Harbor Works of the Inland Steel Co. (Une grosse aciérie américaine. Description des Usines l'Indiana Harbor de l'Inland Steel Co.), A. Reynaud. Revue de Métallurgie, vol. 23, nos. 5 and 6, May and June, 1926, pp. 277–291 and 331–341, 14 figs. Description of blast furnaces, coke ovens, power plants, rolling mills, etc., of this large steel works.

STOKERS

Coal Predrying. Pre-drying of Coal in Conjunction with Mechanical Stokers. Eng. & Boiler House Rev., vol. 40, no. 2, Aug. 1926, pp. 63–65, 2 figs. Points out that whole subject of predrying coal in conjunction with mechanical stokers ought to be reconsidered, especially as regards water-tube boilers.

T

TAPS

Manufacturing. Making Fine Taps in a Modern Tool Shop. Am. Mach., vol. 65, no. 8, Aug. 19, 1926, pp. 317–318, 6 figs. All material is subjected to chemical analysis and physical tests before being racked; different methods employed to make different kinds of taps.

TEMPERATURE MEASUREMENTS

Surface. Measurement of Surface Temperatures, M. W. Boyer and J. Buss. Ind. & Eng. Chem., vol. 18, no. 7, July 1926, pp. 728–729, 2 figs. Portable thermocouple device compensated for heat losses.

TESTING MACHINES

Measuring Dials and Spring Gages. Measuring Dials and Spring Gauges for Testing Machines. Eng. Progress, vol. 7, no. 7, July 1926, p. 184, 2 figs. Testing machines with measuring dials, as developed by firm of Mohr & Federhaff of Mannheim; combination of two power-measuring devices offers advantage that either sliding weight balance or hydraulic balance may be operated singly or both measuring simultaneously.

TEXTILE MACHINERY

Lace-Making. Braiding and Bobbin Machines (Flecht- und Klöppelmaschinen), W. Krumme. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 27, June 3, 1926, pp. 901–906, 26 figs. History of development; description of different types; lace-making machines.

THERMODYNAMICS

Second Law. Interpretation of Entropy. Limit of Validity of the Second Law of Thermodynamics (Betriff der Entropie. Grenzen der Gültigkeit des zweiten Hauptsatzes der Thermodynamik), R. Plank. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 25 and 27, June 19 and July 3, 1926, pp. 841–845 and 915–920, 4 figs.

TIDAL POWER

Utilization. Choice of Current for Utilization of Tidal Power (Sur une forme de courant propre à l'utilisation des marées), L. Schwob. Revue Générale de l'Electricité, vol. 19, no. 22, May 29, 1926, pp. 859–866, 2 figs. In author's belief transformation energy from tidal waves should be effected by means of apparatus of turbine-dynamo type with direct current and variable speed; he recommends and describes Thury distribution system.

TIME STUDY

Metallurgical Plants. Time Studies in Metallurgical Plants (Zeitstudien auf Hüttenwerken), K. Rummel. Stahl u. Eisen, vol. 46, no. 25, June 24, 1926, pp. 840–844, 7 figs. Importance of time studies for piece-work wage making and for improving working processes; examples

TUBES

Testing. How Metal Tubing Should be Tested, N. S. Otey. Iron Age, vol. 118, no. 8, Aug. 19, 1926, pp. 477–480, 11 figs. Tensile properties as affected by shape of test specimens; tube diameter influential factor.

U

UNEMPLOYMENT

Relation to Price Changes. A Statistical Relation Between Unemployment and Price Changes, I. Fisher. Int. Labour Rev., vol. 13, no. 6, June 1926, pp. 785–792, 2 figs. Author finds correlation between rate of price changes and employment, and describes methods by which results are achieved.

V

VALVE GEARS

3-Cylinder Engine. Calculation of the Valve Gear for 3 Cylinder Engines, S. Taga. Soc. Mech. Engrs. (Japan)—Jl., vol. 29, no. 110, June 1926, pp. 374–386, 5 figs. Method of calculation for 3-cylinder valve gear when (1) cylinders are in same plane and cranks are at 120 deg.; (2) when middle cylinder is inclined and cranks are at 120 deg., and (3) when middle-cylinder inclines and crank angles are correspondingly changed. (In Japanese.)

VENTILATION

Rational Basis for. A Rational Basis for Ventilation, J. E. Rush. Am. Soc. of Heat. & Vent. Engrs.—Jl., vol. 32, no. 8, Aug. 1926, pp. 581–616. Historical review of experimental work; composition of air and changes on respiration and combustion; consideration of various constituents of air.

W

WAGES

Basis of. What Determines Wages in Industry, J. D. Cox, Jr. Open Shop Rev., June 1926, pp. 255–264. Relative wages; importance of management; problem of general level of wages; wage levels depend on productive efficiency; law of general wage level; problem of price and wage cycles.

Bonus Systems. See BONUS SYSTEMS.

Systems. Wage Payment and Bonus Systems, J. S. Gray. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 30–32. Objections to day-rate method; piece-work system; why men prefer straight piece-work to various bonus systems; bonus or incentives for foremen; what a bonus plan may accomplish; further extension of incentive systems.

WASTE HEAT

Utilization. Waste-Heat Utilization in Ceramic Works (Abwärmeverwertung in keramischen Betrieben), O. Heller. Berichte der Deutschen Keramischen Gesselschaft, vol. 7, no. 1, Feb. 1926, pp. 1–19, 16 figs. Waste-heat utilization plants of Kahla porcelain works constructed by Bamag-Mequin A. G. for production of steam of 12-atmos. pressure and superheating to 350–400 deg. cent.; 4 to 5 furnaces are required to ensure continuous operation of waste-heat plants.

WATER SOFTENING

Zeolites for. Data on Zeolite Water Softeners, T. J. Ess. Power Plant Eng., vol. 30, no. 16, Aug. 15, 1926, pp. 888–890, 3 figs. Principles involved; methods of determining quantities of salt and zeolites necessary; design data.

WELDING

Aluminum Crankcases. Repairing Oil Saturated Crankcases. Welding Engr., vol. 11, no. 7, July 1926, pp. 37–38, 2 figs. Aluminum castings require careful treatment to remove oil before welding.

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